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towards friendlier systems

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Man and Information Technology: towards friendlier systems

Edited by J.H.F. van Apeldoorn

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The Netherlands Study Centre for Technology Trends (STT) was established in 1968 by the Royal Institution of Engineers in the Netherlands. The Centre has two main aims:

- to evaluate technological trends from the viewpoint of the engineering sciences and to assess their interaction with other social developments;
- to bring its findings to the widest possible notice in order to help build up a more integral picture of the future fabric of Dutch society.

The Centre's studies are a source of information for industry, government authorities, educational bodies and, of course, the interested layman.
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Contents

Foreword

In the past few years electronic information systems have penetrated into every sector and corner of society. This trend will undoubtedly accelerate in the years ahead, and this is why it is so important that the systems should not only operate more effectively, but also that they should be more easy and convenient to use.

One would imagine that the concept of 'user friendliness' would be more than just an advertising slogan or selling point, that it would in fact be a basic design requirement for such systems. The fact that the system designers have not always given it the attention it deserves can probably be traced to two causes. Until now designers have devoted all their energies to making their systems operable. Secondly, the users of the systems were themselves experts, to a greater or lesser degree, so they were able, and willing, to make the necessary personal adjustments demanded by the system.

Gradually, though, there has been a growing recognition of the importance of designing information systems which do have an affinity with the user. No longer are the potential applications determined by technical and economic constraints. So, if the systems are to be used effectively and efficiently, they will have to be adapted to the capacities and limitations of the people who will be using them. Remarkably enough, though, there appears to be little consensus on what it is that constitutes 'user affinity'. There is an almost total lack of any perspective.

The Netherlands Study Centre for Technology Trends felt that the time had come to collate and structure the various views on this subject, and it trusts that this study will contribute to a clearer understanding of the future use of information systems.

The publication now before you represents the joint effort of a large number of Dutch experts in this particular area. The Centre is deeply indebted to them for their work.

Dr A.E. Pannenborg
Chairman of the Board
Netherlands Study Centre
for Technology Trends

I Introduction

by J.H.F. van Apeldoorn

1. The nature of the problem

The introduction of new information and communication systems is having a major impact on society.
This has been widely recognised, in the Netherlands and elsewhere. However, despite the numerous studies on the advent of the so-called 'information society' there is still only a limited understanding and grasp of the specific potential of these new systems and of their effect on society.
The design and structuring of a new information system often take place in a purely technical environment, where the prime considerations are technical and economic constraints. By and large this does not give rise to any major difficulties when the system is used by an expert.
The problem is that most users of the present generation of advanced electronic information systems are non-specialists, and it cannot be assumed *a priori* that they excel in procedural thinking, or that they have been trained in mathematics, administration or document handling.
The lay user therefore has to be taken into account when designing an information system. After all, the use of new systems depends partly on meeting user requirements and adapting the system to human behaviour and thought processes. The fact that this is a major bottleneck is clear from the mismatch which is occasionally noted between the sophisticated potential of the system and its actual use. Systems may also prove ineffective, or may operate below optimum potential. It seems that technically trained designers find it extremely difficult to put themselves in the position of the future user.
Our knowledge of the abilities and inabilities of a user vis-à-vis the information system is limited and uncoordinated, and it is not generally clear how user affinity should be interpreted in this context. The great importance of 'user-friendliness' (or user affinity, which is the term preferred in this report) is now, however, generally recognised. Relevant research is being conducted at various places and within different disciplines. There is also a vast but diffuse store of incidental experience with information systems. One gets the impression that valuable discoveries have been made which, if they were only collated and structured, might indicate ways of comprehending and improving the interaction between man and machine.

It was considerations such as these that prompted the Netherlands Study Centre for Technology Trends (STT) to undertake a study on the user affinity of information systems. One value of such a study is that it can identify how, when and where information systems will be used in the future, and what the consequences of that use will be.

2. Aim of the study

The aim of the study is to examine the way in which information systems could be designed in future in order to achieve a better match with human behaviour and thought processes. It is intended to examine a period extending some 10 years into the future.

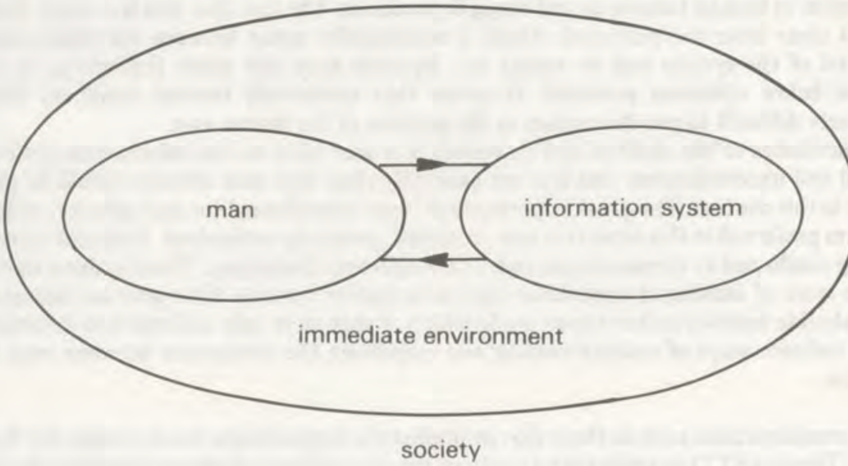
The study is basically aimed at the designers of information systems, but the target group also includes policy planners and decision makers in industry and government who are involved in the introduction of information systems.

3. Subject area

User affinity is a relational concept for indicating the quality of the man-machine relationship. It therefore tells us something about the features of the system under review and the characteristics of the user.

In this study we will be examining the quality of the exchange of information between the user and the technical information system. Man as the user of an information system is the central factor throughout the study. We will be concentrating chiefly on electronic information systems and their users. An information system is defined as an aid and a tool supporting and enhancing man's intellectual functions. 'Information' is interpreted broadly, covering everything that a person can know, observe or infer.

In interpreting the concept of user affinity we distinguish between three levels of man-machine interaction. On the first level user affinity concerns the effectiveness and personal comfort of the exchange of information between the information system and its direct user. On the second level it is seen as a factor determining the operation of the man-machine system as an entity in its immediate environment or within the confines of the organisation involved. On the third level user affinity covers the question of reciprocity. How will the use of information systems affect human behaviour and thinking in the years ahead?



The emphasis of the study will be on the first level: the effectiveness and personal comfort of the exchange of information between man and technical information system.

4. The user

Man as the user of an information system is the central element in this study. This means that all the aspects of operating the information system are viewed primarily from the standpoint of the immediate user. Who is the user? The user is the person who employs the information system to do the task for which it was designed – a consumer in the case of viewdata, a lawyer in the case of a legal data base, or a secretary in the case of a word processor. Broadly speaking users can be divided into three categories.

1. The general public, who encounter data processing systems in numerous situations but who have had no specialist training in their use.
2. The non-specialist user, for whom the interaction with the information system is just part of his or her daily work.
3. The information specialist, whose job is largely or entirely devoted to the use of information systems.

The present study is mainly concerned with the first two groups. Needless to say the immediate user is not the only one who is intimately involved with the information system, particularly when it is a question of the effectiveness of the man-machine system. However, in this study we will be concentrating on the system operator, and will only refer briefly to the consequences for other individuals when they touch on system effectiveness. In a control room it is the operator who is the user; the supervisor is not regarded as such. The purpose of a computer-aided instruction system is didactic, so the pupil is the user. The teacher or instructor is only the user when the lessons are being planned. In the case of a flight reservation system the terminal operator is the user; the passenger is not.
User affinity can mean very different things to different users, and will generally depend on the user's education, experience, intellectual ability, requirements, expectations, goals and tasks. The main concern for 'naive' users is to learn how to handle the system, and the same may apply to sporadic users. Different aspects come into play when the user is experienced. However, a naive user can become experienced after a period of time, so in this respect user affinity is a moving target. A user-friendly system adapts to the degree of experience and prior knowlegde of the user.
The user's motivation and role affect the way in which he experiences the information system. In addition, physical and psychological characteristics differ from one person to the next, and they may alter as time passes. The designer of the information system has to take all these factors into account.

5. Design

A user-friendly information system is geared to human characteristics, and this means that a knowledge of the limitations and potential of present and future systems and, above all, an understanding of the potential and limitations of human performance are crucial to the design of such a system.
When man-machine systems are designed, tasks are apportioned between man and machine. It is therefore useful to have a comparison of the strong and weak points of human beings and machines. One such comparison is given by Coburn [1] (see Table 1).

6. The function of the information system

The information system is designed to carry out a task which is geared to the operation of the entire man-machine system in its immediate environment or within a specific organisation. There are so many possible uses of information systems that it would be impracticable to give a resumé. However, it is possible to distinguish between various application areas, each with its own characteristic features. In each case the human contribution and the nature of the information differ, depending on whether it is a communication process, a learning process, recreation, the recording and retrieval of knowledge, mathematical calculation, management and organisation, or physical process control. The human contribution, and especially the degree of control over the process, are important factors governing user-friendliness. They are greatest in the case of communication, but are far less crucial in the case of a control room operator dealing with a highly automated process, who has to react to infrequent signals initiated by the system. A data base search may involve a procedure employing commands formulated by the user, or one whereby the operator makes a choice from alternatives presented by the system.

The nature of the information also plays a important role. Time is a transitory phenomenon; the observation that one is on time is information of a totally different nature. Information selection and information relevance may present major problems. There is no longer any technical or economic obstacle to processing a vast amount of data using information and communication techniques. The obstacle for the user is not usually the lack of information, but its relevance.

7. Components of the man-machine system

In the man-machine system one makes a distinction between the human element and the technical element, with input and output processes being employed on both sides. Man acquires information using his senses, chiefly sound and sight and, to a far lesser extent in this context, smell, taste and touch.

The human operator generally uses his hands to insert information into the technical element, but very occasionally the voice or the eye may be used.

The technical element uses technical input and output processes. A distinction is also usually made between hardware and software.

In a user-friendly system the information processing element will be complementary to man's ability to process information, while its information input and output will be geared to the operator's perception and physique.

8. Project structure and report layout

This study is based on practical experience with information systems. The use of a theoretical framework for the project structure was rejected. Information systems are above all extensions of the human brain, unlike aids which serve as extensions of bone, muscle or the senses. Our understanding of the working of the human brain is so inadequate that it could not possibly be used to establish a theoretical framework for a study of this kind.

The function of the information system and its potential and limitations were also discarded as the point of departure. It is clear from the many publications which have approached the question from this angle that technical aspects (and the associated jargon) continue to predominate, precluding any general comparison with what we know about human behaviour, which is relegated to the background.

These considerations decided us to base the project on practical experience. The first step was to examine the question of user affinity in a number of sectors where information systems are actually in use. The object was to identify the main aspects of user affinity and to pinpoint the problems. This produced the seven case histories contained in Chapter II.

The authors of those histories then produced a synthesis of their practical findings, which yielded the classification of user affinity aspects contained in Chapter III. The authors also listed a series of questions which had been raised during discussions on aspects of user affinity.

Chapter IV gives a view of the prospects of improving user affinity as seen by specialists from various disciplines. Those disciplines were chosen on the basis of the kind of issues

raised in the synthesis and by the list of questions. The contributions in Chapter IV are partly a reflection of the general views held in a particular discipline, and partly an attempt to give a specific answer to some of the questions. The questions are accordingly printed immediately preceding the section in which they are raised.
The report closes with Chapter V, which lists the main findings and presents a few of the open questions still remaining.

9. Literature survey

A limited literature survey was carried out for the purposes of this report. The aim was to discover how the concept of user friendliness is interpreted and to ascertain what sort of recommendations are being made for improvements in this area.
The literature was assembled with the aid of documentary data bases, by manual searches through bibliographies, and by enlisting the cooperation of a number of specialists. The report of this survey (which is in Dutch only) [2] is not being published, but will be supplied by STT on request. The works consulted will be found in the literature list at the end of this report [3-58].
The various sources used to compile this survey almost invariably gave different results, so it can only be concluded that the total compilation is probably far from complete. One reason for this is undoubtedly that user friendliness is not a generally accepted or institutionalised concept. It can be approached from a wide range of disciplines and areas of application. Documentary files, on the other hand, are often arranged by specific disciplines or applications.
The searches in the data bases were in themselves a salutary illustration of user friendliness. A specialist intermediary had to be called in, and the dialogue with the system proved to be fairly primitive. The limitations of the internal structure of the system also had an adverse effect on the search process.
The results of the literature survey are frankly disappointing, and no general picture can be drawn from them.
The main conclusions are as follows.

- The importance of user affinity or user friendliness is clearly recognised.
- There is no consensus on the definition of user friendliness. In the majority of cases there is an emphasis on effective interface and dialogue.
- The concept of user friendliness is analysed in many different ways.
- It is possible to distinguish five approaches, with recommendations being made on the basis of the work or task of the user, experimental research, theoretical psychological expertise, practical experience and common sense, and an analysis of the information system.
- The five approaches yield five groups of sub-aspects of user friendliness. The variety of definitions conceals the fact that the aspects are sometimes the same.
- Some of the recommendations are trivial, not specific to information systems, and occasionally trite.
- The approach to the problem is highly analytical in character.
- The development of the sub-aspects is sometimes rudimentary.
- Many of the authors restricted themselves to minutiae in order to come up with any recommendations at all.
- The validity of the recommendations is sometimes, but not always, backed by experiment.
- The recommendations do not cover all aspects of user friendliness. For instance, there is little or no discussion of flexibility (adaptability), congruence (between the structure of

the information system and that of the organisation), standardisation, accessibility of the system, language or privacy.
- The accent is often on the form of dialogue.
- Although the literature does not back our definition entirely, no interpretations were found which are fundamentally different.

10. Steering committee, project groups and other contributors

The Netherlands Study Centre for Technology Trends is extremely grateful to all who have worked on this project. The members of the steering committee and project groups gave their services free of charge and at a considerable sacrifice of their free time.

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Among the many other contributors to the study special mention must be made of the following individuals (who bear no responsibility for the content of the report).

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The entire project was prepared and supervised by J.H.F. van Apeldoorn, project leader at the Netherlands Study Centre for Technology Trends, who also chaired all the project groups.

The report was translated by Michael Hoyle and H.S. Lake.
Editorial assistant: Mrs R.M.P.G. Otten.

Table 1 Comparison of Human and Machine Capabilities for Performing Various Tasks [1]

SENSING AND MONITORING

Man	Machine
Men are poor monitors of infrequent events or of events which occur frequently over a long period of time.	Machines can be constructed to detect reliably infrequent events and events which occur frequently over a long period of time.
Man can interpret an input signal even when subject to distraction, high noise, or message gap.	Machines perform well only in a generally clean, noise-free environment.
Man is a selecting mechanism and can adjust to sense specific inputs.	Machines are fixed sensing mechanisms, operating only on that which has been programmed for them.
Man has very low absolute thresholds for sensing (e.g., vision, audition, taction).	Machines, to have the same capability, become extremely expensive.
Expectation or cognitive set may lead an operator to 'see what he expects or wants to see'.	Machines do not exercise these processes.

INFORMATION PROCESSING

Man	Machine
Man complements the machine by aiding in sensing, extrapolating, decision making, goal setting, monitoring, and evaluating.	Machines have no capacity for performance different from that originally designed.
Man can acquire and report information incidental to the primary mission.	Machines cannot do this.
Man can perform time contingency analyses and predict events in unusual situations.	Corresponding machines do very poorly.
Man generally requires a review or rehearsal period before making decisions based on items in memory.	Machines go directly to stored information for decision.
Man has a built-in response latency of about 200 milliseconds in a go/no-go situation.	Machines need to have virtually no response latency.
Man is not well adapted to a high-speed, accurate search of a large volume of information.	Computers are designed to do just this.
Man does not always follow an optimum strategy.	Machines will always follow the strategy designed into them.
Man has an extremely limited short-term memory for factual material.	Machines may have as much short-term (buffer) memory as can be afforded.

Man	Machine
Man is not well suited to data coding, amplification, or transformation tasks.	Machines are well suited to these kinds of tasks.
Human performance is degraded by fatigue and boredom.	Machine performance is degraded only by wearing out or by lack of calibration.
Man saturates quickly in terms of the number of things he can do and the duration of his effort.	Machines can do one thing at a time so fast that they seem to do many things at once, for a long period of time.
The human has a limited channel capacity.	Machines may have as much channel capacity as can be afforded.
Men are subject to anxiety which may affect their performance efficiency.	Machines are not subject to this factor.
Man is dependent upon his social environment, both present and remembered.	Machines have no social environment.
Man can recognise and use information redundancy (pattern) in the real world to simplify complex situations.	Machines have limited perceptual constancy and are very expensive.
Man has high tolerance for ambiguity, uncertainty, and vagueness.	Machines are highly limited by ambiguity and uncertainty in input.
Man has excellent long-term memory for related events.	Machines, to have the same capability, become extremely expensive.
Man can become highly flexible in terms of task performance.	Machines are relatively inflexible.
Man can improvise and exercise judgment based on long-term memory and recall.	Machines cannot exercise judgment; they are best at routine, repetitive functions.
Man can perform under transient overload – his performance degrades gracefully.	Machines stop under overload-generally fail all at once.
Man can make inductive decisions in novel situations; can generalise.	Machines have little or no capability for induction or generalisation.
Man can modify his performance as a function of experience; he can learn 'to learn'.	Trial and error behaviour is not characteristic of machines.
Man can override his own actions should the need arise.	Machines can do only what they are built to do.
Man complements the machine in the sense that he can use it in spite of design failures, for a different task, or use it more efficiently than it was designed for.	Machines have no such capability.

CONTROL

Man	Machine
Man can generate only relatively small forces, and cannot exert large forces for very long or very smoothly.	Machines can generate and exert forces as needed.
When performing a tracking task, man requires frequent reprogramming; he does best when changes are under 3 radians/second.	Machines do not have such limitations.
Much of human mobility is predicated and based on gravity relationships.	Machines may be built which perform independently of gravity.
Human control functions are adversely affected by high g-forces.	Machine control functions may be designed to be largely unaffected by g-force.
Humans are subject to coriolis effects, motion sickness, disorientation, etc.	Machines are not subject to these effects.
Unselected individuals differ greatly among themselves.	Individual differences among machines are small.
Human performance is degraded by long duty periods, repetitive tasks, and cramped or unchanged positions.	Machines are less affected by long duty periods, perform repetitive tasks well; some may be restricted by position.

II Case histories

1. Introduction

This chapter consists of seven case histories describing experiences with information systems. The object is to show from practical experience what the main features of user affinity are and where problems occur. They are not, therefore, exhaustive studies of all facets of the use of information systems in the areas concerned, but concentrate solely on user affinity. This means that, within the confines of the interpretation of the concept in each study, we place the user at the centre of the system and look at his effectiveness, his personal comfort when using the system, and any organisational aspects which may affect him.

There is a certain degree of arbitrariness in any selection of examples, so the list could well have been different. In this case the selection was based on the following four considerations.
The goal was to give the broadest possible survey of user-affinity aspects in as many conceivable situations as possible, bearing in mind the constraint that the studies are aimed chiefly at non-specialists. Each study had to present a coherent insight into practical experience with information systems in the field concerned.
Although the study focuses chiefly on electronic systems, it was not a condition that all the examples should necessarily do the same. Needless to say, there were practical reasons for limiting the number and size of contributions. The requirement that the studies should deal with practical experience ruled out very recent innovations, such as management information systems, personal computers, viewdata or consumer electronics.

The examples are:
- control rooms in process industries;
- route information systems (signposts etc.);
- the parliamentary data processing centre in The Hague;
- the BAZIS hospital information system;
- the CORDA flight reservation system;
- information systems in teaching;
- the PLATO system and computer-based learning.

A great deal of human factors research has been done on control rooms. The control room operator often receives special training and may be seen as an experienced user. Route information systems were chosen because they have to be used by such a large cross-section of the community. They are largely non-electronic, static and non-interactive. The parliamentary computing centre is an example of a documentary information system used by trained and experienced intermediaries. The hospital system has been included because it is used for day-to-day tasks by users whose thoughts are far removed from those of the computer specialist. Flight reservations are made by people with brief training who are spread all over the world and who have widely differing cultural backgrounds. Finally, the article on information systems in education gives examples of non-computerised systems to provide an overview of the chief factors affecting the acceptance of technical teaching aids, and thus complements the example of the PLATO system, which discusses the user affinity of computer-assisted learning.

2. Control rooms and process automation systems

by R.N. Pikaar

2.1 Process control systems

2.1.1 Definition

A process control system is a system in which one or more task performers (operators) keep, or try to keep, a complex and more or less automated technical system in a previously defined state (regulatory control), or bring or try to bring the system to that state (sequence control).

Process control systems are found in the process industry, which in this case is a fairly broad concept embracing refineries, chemical plants, the steel industry, power stations, oil and gas drilling platforms, and so on. In many cases, then, the process concerned will be continuous, though batch processing (e.g. by a chemical process taking a few hours, or the smelting process in the steel industry) is also included. Discrete manufacturing systems, such as assembly lines, do not fall under this heading.

As the above definition implies, a process control system consists of two parts: the human element and the machine element. Between the two lies the man-machine interface. In a process control system the man-machine interface is characterised by two-way traffic. The machinery feeds information to the man, and the man feeds control signals to the machinery.

2.1.2 The technological evolution of process control systems

In the past, process machinery was controlled by the operator in the field, standing by the machinery itself. The man-machine interface in this case consisted of meters and gauges on the machinery, and stop valves, switches etc.
The technology of instrumentation systems eventually made it possible to operate valves from a distance and to present measurement data at a distance from the point of measurement. It thus became possible to centralise process operation in a control room.

Later on the instrumentation industry developed what is known as the analogue controller. This is an instrument which automatically carries out adjustments in order to eliminate the difference between the actual value of a process variable (e.g. a temperature, or the rate of flow of a fluid) and a desired value set by the operator. The automatic controller would then, for example, adjust the position of a control valve. The first analogue controllers were operated pneumatically. Much of the operator's control task was taken over by the analogue controller.

At first the instruments in the control room were large and took up long expanses of wall space. On the human side of the process control system the distinction between indoor and outdoor tasks made its appearance.

The introduction of the computer did not pass the process industry by. It became possible to link data from analogue controllers at particular stages in the process by means of software. The analogue controller was designed to control a single process variable. The computer makes it possible, in principle, to achieve the optimum control of all the process variables as a coherent whole, both in their interrelationships and interactions, without human intervention.

The most recent major development in instrumentation systems has been the replacement of the analogue controller by a digital version (a microprocessor), though the functional qualities remain the same.

2.1.3 Control rooms

In the chemicals sector (refining, chemicals, etc.) it is common practice to bring all the indoor tasks in the process control system under one roof. This means that there are several operators in one room, sitting in front of consoles and/or instrument panels (the interface). The same building will generally also house the computers. In other sectors of the process industry, however, small control cabins in which a single operator carries out his controlling task are not unusual.

The actual situations prevailing in control rooms vary widely from case to case, depending largely on the year in which the process control system was designed. There are control rooms still working exclusively with analogue instruments, but the combination of analogue instrumentation (wall panels and consoles with meters, switches, etc.) and a process computer, dating from the years between 1970 and 1975, is quite common. Under normal process conditions the operator has a watchdog function; in abnormal process conditions – start-up, shut-down, or when faults arise (process upsets) – he controls the process manually.

Since about 1975 new process control systems have almost always been equipped with digital controllers and computers. One consequence of this has been the superseding of almost all instrumentation by video displays and keyboards.
This has not meant a change in the operator's watchdog function, but it has, of course, affected the way he carries out that task. More specifically, it has modified the interface with the processing part of the system.
There is now a tendency to build an increasingly high degree of computer 'intelligence' into the system. This means that the process computer takes over the control of the process in a growing range of operating conditions. What remains – the most difficult process conditions – is still left to the operator.

In the chemical industry not all the available process information is fed to the operator through video displays. Historical information is given by separate pen-recorders, and warning panels and alarm systems are still wired direct (i.e. not via the computer), either because the computer is not yet considered sufficiently reliable, or because it is a legal requirement for reasons of safety.
Throughout the process industry it is common practice for control rooms equipped with visual display instrumentation to be fitted with panels of process flow diagrams. In a power station, for example, there are vast wall-mounted charts of the electricity grid.
For the rest of this chapter we shall concentrate on the situation in which digital controllers are employed. Broadly speaking, any new design for a process control system is going to employ that kind of system.

2.2 Technological features

2.2.1 Process equipment and machinery

In any process industry there will be a desire to optimise the process operation, i.e. one of the goals will be improved product quality and increased efficiency.
Technological changes in instrumentation systems and the desire to optimise process operation make it both possible and desirable to integrate smaller process equipment and machinery units. To take an example: if a particular plant uses a great deal of high-pressure steam and another plant produces it in vast quantities, the logical step from the point of view of energy conservation is to link the two. However, this does mean that the process in one plant might affect that in the other, which would make the whole operation more complex. There are, incidentally, processes which can only be run precisely because of the calculating capacity and speed of the computer.

Process plants can vary in their reliability. In the chemical and steel industries, for example, much of the plant (pumps, furnaces, valves, etc.) is highly sensitive to wear and tear. Sensors can become unreliable, pumps slowly but surely begin to need maintenance at increasingly short intervals, and so on. Then again, it takes only a very small fire on, say, a catalytic cracking column in an oil refinery to melt wiring which may include the link to the computer, thus making it impossible for valves to be operated from the control room and making it difficult for the operator in the control room to oversee the whole process and coordinate its control systems. Fail-safe shut-down systems are incorporated into all essential systems that are liable to break down, so that should the control system fail, valves automatically move to the safe position, often leading to a complete plant shut-down.

The reliability, and hence the safety, of industrial plant can be increased greatly by building two identical units at sensitive parts of the process, so equipped that the process is automatically switched to the second unit when the first one fails. Nuclear power stations are obvious candidates for such systems. There are also plants in which the failure of one unit has no major consequences, and where the whole plant can be shut down, either automatically or manually. Unlike his counterpart in the process industry, the operator then has more of a watchdog function, since repairs and maintenance are carried out on a non-functioning piece of equipment of machinery and thus do not affect the process. Control room operators are not involved in repairs and maintenance.

2.2.2 The instrumentation system

It is an important feature of conventional control room instrumentation systems (analogue controllers, etc.) that the operator can see the state of his particular part of the process at a single glance. The picture that the operator forms of the process is more easily arrived at if everything is easy to oversee, or at least if the instrument panels are easy to see and understand. Operating the man-machine interface is done by turning knobs, moving switches, and so on. These actions are closely related to the plant in the field: to open a valve slightly you turn a knob slightly.

When computers were introduced into the process industry (1965) to take over part of the job of controlling processes and to turn measurement data into information which the operator in the control room could use, the conventional instrument panels were joined by visual display screens. The character of the modern control room is determined by the screen and keyboard (the visual display unit or VDU) as the man-machine interface.

Alarm and telemetry systems are kept separate. Although control room operators often have more than one screen providing them with information, the same degree or detail of readily accessible information cannot be achieved as in the conventional control room.

The modern computerised instrumentation system may operate at one or more levels. At the lowest level there are a series of microprocessors, each of which controls a limited number of control circuits (perhaps eight). One level higher, software links the individual control circuits in order to optimise process operation. The computer used for this purpose is generally referred to as the process computer. This, in turn, can be part of a network of other computer systems capable of interacting. To take an example from the oil refining industry: the purchasing and sales department of a refinery will have information, updated daily, on the costs and selling prices of the range of products which the refinery can produce. The process computer controls the processes so that the desired quantities of the desired range of products flow to the storage tanks. If the computers of the two departments are linked by software things can be so arranged that the price aspect automatically adjusts part or all of the refining process.

2.3 Man and the process control system

In addition to the machine element (the process plant, instrumentation, etc.), a process control system also involves a human element, which we shall discuss here.
The primary human task-performer is the operator in the control room. In modern instrumentation systems the computer and the operator jointly carry out the task of controlling and monitoring the process. What part of this task is carried out by the computer and what part is left to the operator depends on the degree of computerisation, the intelligence of the instrumentation system and the extent to which they are used in the organisation concerned.

The work of the control room operator is generally carried out by highly experienced staff, generally with secondary technical school backgrounds (some such schools run courses for process operators). The work also demands a considerable knowledge and understanding of the process plant itself, and operators naturally also receive on-site training (including a period of apprenticeship to a more experienced operator, study of the process dynamics, and possibly working with a process simulator). Some experience has also been gained using operators with technical college backgrounds, notably at power stations, but it has been found that for staff with that level of formal training the work of the control room operator brings little job satisfaction.

The control room operator's position may be occupied by individuals who work exclusively in the control room. However, it is also possible to have all operators take turns at jobs on the plant itself and in the control room, in which case they are better informed about the actual state of the plant. Work is generally done in shifts (certainly where the process is a continuous one).

A single control room operator position is the pivot around which several human tasks are organised. In direct relation to the process control system (since it is part of it) is the work that has to be carried out on the plant itself. A great deal of monitoring work has to be done on the individual machines and pieces of equipment: checks for leaks, wear and tear, and on the performance and standard of maintenance work. Much maintenance work in the process industry is carried out without interrupting the process.
If the control room operator has doubts about the reliability of the information he is receiv-

ing from the computer, the plant operator must have a look. If the computer control of a regulator valve fails, the valve must be operated by an operator on the spot. Each control room operator position may be working with between two and four plant operator positions.
In short, the control room operator is part of a team of people, including operators in the field and possibly other control room operators. Computer experts, programmers and process technologists work either in the control room or at least in direct interaction with the instrumentation system. Programmers and process technologists hold regular consultations with the operator (for example, when new systems or controls are to be implemented).
The operators' immediate superiors and the central management both use the information contained in the process control system to help them formulate production policy. In principle, the computer system also makes it possible to measure and visualise the performance of individual operators, teams, shifts etc.

2.4 A closer examination of the man-machine interface

In the modern instrumentation system the man-machine interface consists of a large console carrying a number of screens. Information is also presented by panels of warning lights and by pen-recorders. Input devices will be discussed later. Generally speaking the control room operator will be dealing with two different control and monitoring systems: the instrumentation system (microprocessor-controlled control circuits) and the process computer, which represents a higher order (computer intelligence) of process control.

As we saw in Section 2.1.2, microprocessor-controlled instrumentation evolved from conventional instrumentation. As a result the presentation of information still largely resembles the traditional controllers: that is, the external appearance of those controllers is drawn on the screen.

The cathode ray tube cannot display all the information that is available at the same time, nor indeed can it handle all the information required by the operator. For this reason, information is generally packaged in a hierarchical system. At the highest level the operator sees a general picture, generally in the form of one value for each important process variable. Data on some 200 process variables may be displayed at any one time.
From this overall view it is then possible, using function keys, to call up particular categories of information, such as data from one complete unit of the plant (which might consist of 4 to 8 groups of controllers).
One level further down it might then be possible to look at the details of one of these groups of controllers. Apart from the actual value of the process variable concerned, the information displayed will also include the set-point value, upper and lower limits, and so on. Also within the information hierarchy will be tables of historical information, or perhaps diagrams of process units and the like.

The process computer can also provide the operator with information after it has been processed. As with the instrumentation system, the way in which this information is presented is largely predetermined, but there are also ways of programming new forms of presentation. Process information can be shown in the form of process diagrams; higher-order process control programs can be presented schematically for the operator's benefit; and so on.

For process control, in so far as this is his job, the operator uses a keyboard. Calling up information is generally done by using function keys: one strike of the relevant key initiates

the presentation of the information required. In all systems, control operations require the keying in of various data by means of a numerical keypad or alphanumeric keyboard.
Besides keyboards and keypads, however, there are a multitude of other possible input devices. As a rule these will be means of moving the cursor over the screen – trackerballs, joysticks, light pens etc. Sometime a light pen or a touch-sensitive screen will be used for giving commands (e.g. starting a pump by touching a picture of a pump on the screen).

2.5 User affinity

2.5.1 The man-machine interface

As noted in the previous section, in principle all the information relating to the process is available on visual display units, but because of the limited area of the screens it cannot all be displayed at once (as in conventional systems). The operator must ask for information, which means that he has to carry out one or more operations, and this takes time. In addition, the serial presentation of information puts severe mental pressure on the operator: he has to remember more information. Operators find the mental load much greater than in the conventional situation.

Not very much is known about the form in which process information can be presented on cathode ray tubes (there are guidelines as to viewing distance, symbol size, etc.), and still less is the available knowledge applied by manufacturers.
One striking example of this is the presentation of historical information. There is still no adequate way of presenting trend information on the screen, despite the fact that all systems have pictures designed to do it. Some of the problems here are: adequate screen resolution, too low a sampling time (so that rapid or transitory fluctuations in a signal are lost) and above all the limited number of signals that can be looked at and compared simultaneously on a single screen.
This is why the modern control room still contains conventional pen-recorders: they provide the operator with highly essential information about the status of the process.

Many instrumentation systems have colour screens, and the availablilty of colour is frequently utilised. Colour is one of the strongest coding parameters available for the presentation of information, and has a high attention-drawing capability. However, in many situations there is no need to use a strong coding parameter: position, shape, or differences in intensity may do the job better or equally well.
Examples of the poor use of colour include colours which are too far apart in the spectrum, which is tiring on the eyes. Despite this, it is a not uncommon feature of some displays, even in the same display format.
Entire areas of the screen, perhaps representing the contents of a storage tank, are often filled with colour. Where the colour is bright (i.e. with a high intensity) it may easily produce a screen in which one area predominates, although there may be absolutely no reason for it to do so in terms of process control requirements. A carefully considered and restrained use of colour is found only too rarely. It is a point that needs remedying.

One important aspect of presenting process information is that the manner of presentation should accord with the idea (or internal representation) that the operator himself has of the process. What information does the operator use to carry out his task? And what information is superfluous?

As regards input devices it is worth noting that the choice made by the manufacturer may not always be the best from the operator's point of view. In particular, devices like tracker-balls, joysticks, etc. tend to be used more because the manufacturer thinks they are technologically attractive than because they are functionally necessary. In many cases a keyboard with function keys would be perfectly satisfactory. Practical guidelines are available for the design of input devices and of the control room operator's workplace.

2.5.2 Work organisation

There is a tendency to make the computer take over as much as possible of the process control task. Software is developed for starting up and shutting down plant and for coping with known and regularly occurring process disturbances. The result is to restrict the operator's task to reacting to and dealing with little-known and difficult problems. The result has been described in the literature as an uneven balance of '99% boredom and 1% terror', with the possibility of the wrong action being taken. One only has to think of Three Mile Island.

There is a widely held view that progressive automation leads to a manpower saving. Whether this is indeed the case is a debatable point. In the first place the number of staff (directly operational staff) on a shift is already regarded as the minimum for the proper containment and management of calamities and the like, and in the second place it is debatable whether automation lightens the overall burden on the operator: the computer may take over control functions, but the mental task to be performed by the operator becomes more onerous.

There is also a tendency to make a clearer differentiation between the level of the operator in the field and the operator in the control room. The argument is that the operator in the control room should be of a higher level of competence because now that the computer takes all the routine decisions the remaining decision-making authority is at a higher level (mental load). Once again, it is debatable whether, from the point of view of optimal process control, this argument is a sensible one. For the running of process control systems it may be necessary for the control room operator to have a thorough and up-to-date knowledge of the installations under his control. He can only be in possession of that knowledge if he regularly carries out the field jobs.
A further dimension is added to this problem by the difference in status between field operators and the dedicated console operator.

The degree of cooperation between control room operators, and between control room operators and field operators and supervisors, can have a significant effect on the quality of process control. Cases have been recorded in which poor cooperation, leading to poor communication about what was happening in the process, has led to major process upsets (regardless of the degree of computerisation).

Erosion of the operator's task may be a negative aspect. On the other hand, experience has shown that the technically more competent operator is better able to recognise the greater potential of the new digital control equipment. Control circuits can be made more complex, and then demand a higher level of insight into their operation. Operators are a useful source of suggestions for improvements in operating under differing conditions. In many installations a continuous stream of new values has to be fed into the system depending on changing market conditions and fluctuating feedstock composition. For a chemical plant where the product is always the same, the situation is of course quite different.

Highly automated systems provide management with the means of monitoring operators' performance. Process upsets can be analysed afterwards, and the resulting data can be used to improve the future running of the plant. However, the same data can also be used to identify the guilty party or parties.

2.5.3 The design of process control systems

In the present design of process control systems there is a strong emphasis on the technological side of the design: a desire to see how far it is possible to go using modern technology.
In this context, instrumentation systems are generally assessed on the quantity of the information available. The important point for the user, though, is the quality of the information he receives. Information must be attuned to the needs of the user.

The design of a good process control system demands a balanced input at every design stage of the technological and human aspects of the system.

2.5.4 Summary of positive and negative experiences

Positive experience with modern process control systems has been gained chiefly in the area of operating economy, since they have made it possible to optimise the way processes are operated and managed. However, the introduction of the new technology has not led to any large-scale manpower savings.

Negative experience is emphatically related to the human side of process control systems.

- More onerous mental loads on operators.
- The threat of erosion of the operator's task due to the computer system taking over more and more of the individual tasks. There is too little recognition of other ways of enriching the operator's task.
- There is insufficient knowledge of information presentation on visual displays. Among other things, the presentation of trend information has yet to be mastered.
- The design of process control systems is still too one-sided. Not enough attention is being paid to the effects of organisational aspects and the wishes and needs of the ultimate user.

For further reading see: [59-64]

3. Route information systems

by H.L. Oei

3.1 Introduction

This article examines the user-affinity aspects of route information systems, particularly signposting. The user is taken to be the road-user.
Since the various systems of providing route information are closely interrelated, attention will also be paid their interrelation, and the whole subject will be regarded within the general context of the purpose of route information systems. Apart from conventional fixed road signs, the flexible systems which have been in use abroad for some years will also be

discussed, and reference will be made to some which are still at the experimental stage.

3.2 The purpose of route information

Goverment policy is designed to ensure that our roads and the way they are used are ordered in such a way that traffic is directed along the most appropriate routes according to the season and time of day and the nature, point of origin and destination of that traffic. Efforts are being made to order road traffic on the basis of a functional classification of the road network. The way in which roads are designed and equipped must be attuned to their function and to the traffic flow commensurate with that function.
Problems relating to road safety and the flow of traffic may be attributed, in this context, to a discrepancy between function and equipment and the actual use of the road. Route information systems which are attuned to the function of the road network can help to ensure that traffic actually takes the routes intended for it. Route information systems must help the road-user orientate himself and choose and follow the right route. Flexible systems are designed to indicate to drivers their best routes in the circumstances prevailing at the time they are needed.

In this article the accent is on motorised traffic as the user or consumer. The range of user characteristics is wide: experienced/inexperienced, amateur/professional, with/without navigator, young/old, intelligent/unintelligent, and so on. The system must be designed in such a way that a large percentage of road-users can use it effectively.[1] Different reasons for a journey may result in different criteria for the most appropriate route: the shortest, fastest, most functional, most economical, most comfortable, least stressful or most beautiful. Sometimes there is no question of a choice being made, simply because the driver is unaware of the existence of viable alternative routes. All these factors have to be taken into consideration in the design of route information systems.

3.3 Route information systems

3.3.1 General

This section describes the various sources of route information and the connection between them. Particular attention will be paid to their user-affinity aspects.
The formal sources of route information are: maps (general maps and road maps), alternative route maps, fixed signposting, alternative route signposting (fixed or flexible), traffic information over the air, visual route information on a screen, individual route information in the vehicle. Information gathered from locals and passersby is also a possible, albeit informal, source.
The better a driver's knowledge of the locality through which he is driving, whether acquired from maps or experience, the less will be his need for route information *en route* (unexpected eventualities excepted). On the other hand where there is a lack of experience it will be necessary to study the map at home.
If the required amount of prior knowledge is very large, there is a real chance that this homework will not be done sufficiently thoroughly, and that the signposting will be understood poorly or not at all. This is where one should ask whether the system has not been made unnecessarily complex.[2] Driver education would probably lighten the route-selection task.

In the majority of route information systems not enough attention has been paid to the preferences of the road-user. Moreover, route information systems tend not to be considered as part of a larger system, as having an important role to play in improving the entire transport system. In other words, route information systems are too often regarded in isolation.

3.3.2 Maps

There are many different sorts of map available in the Netherlands, and no two are alike. Improvements could be made on the following points.

- Unambiguous and functional road classification. This requires central government, provincial and local authorities to draw up an unambiguous, consistent and coherent functional classification of road networks.
- Unambiguous road type designation.
- A road or route numbering system linked to the two points referred to above. The present numbering system consists of European highways (E-roads), 'autosnelwegen' (motorways: A-roads), non-motorways (N-roads) and 'stadsroutes' (urban routes, 'S-roads'). Only a small proportion of roads outside (or functionally outside) built-up areas are numbered according to this system. Consideration should also be given to the desirability of numbering secondary and tertiary routes. Planning a route, pinpointing one's position and following a route would be facilitated. Needless to say, it is not practical to number all urban streets.
- Exit names do not appear on most maps.
- There is no system of exit numbering, although it would eliminate ambiguity and allow drivers to anticipate better by counting the number of exits still to go.
- Information on urban routeing systems can only be included on new maps to a very limited extent.
- Points of reference regularly mentioned on broadcast traffic information bulletins are sometimes not marked on maps (e.g. the Poot van Metz and Hellegatsplein).
- Locating place-names, roundabouts etc. on the map is often difficult because there is no index.

Another question that still needs to be answered is whether or not map design should take more account of the criteria used by drivers when they choose a route.
Finally, there ought to be more standardisation of maps on a European basis.

3.3.3 Alternative route information on maps

Maps do not carry information on alternative routes, which would be useful in the event of serious unexpected congestion resulting from, say, an accident. The CPVC (Central Police Traffic Commission) has worked out an alternative routes scheme, part of which consists of a map of an actual national network of alternative routes. Numbering these routes systematically and marking them both on maps and along the roadside would be extremely useful to motorists, assuming that they were provided with the right map.
There are no alternative routes in the case of less serious congestion. This is due to the restricted capacity of the lower-order roads throughout much of the country.
In France the motorist can buy special maps showing peak traffic dates and the alternative routes to be taken during peak periods. This information matches that on special roadside signs.

3.3.4 Normal signposting

Blue-and-white signs show final destinations, primary destinations and important places

(see diagram). Particular destinations such as industrial estates, recreational areas or airfields are shown by black letters on a white background.
Quite a lot of attention has been paid to the perception aspects of the signs and lettering, and in fact there are few problems in that regard. Moreover, signposts and other direction signs are generally positioned in such a way as to make collision with them unlikely, or they may be placed behind crash barriers or guard rails. They are also constructed in such a way that they collapse on impact and present little danger in the event of a collision.
One problem for the road-user is that when he is planning his route he selects place-names from the map for orientation purposes but cannot be sure that the same names will appear on the road signs along the route. If they do not this can give rise to confusion, particularly where a driver has to decide which way to turn. Because of the limited amount of information that it was felt appropriate to include on road signs in the Netherlands, problems of this kind have a good chance of occurring.
It is possible to compensate for this drawback by making a better study of the map before setting out. However, this in turn gives rise to more problems, such as remembering the information, although this could be corrected by writing down the selected route before leaving home.
These is a need for a re-examination of the criteria applied in indicating routes in the Netherlands. There are places where a relatively long-distance route is led along roads of a lower functional class through built-up areas, even though there is a motorway link in the vicinity which just happens to be slightly longer. Then again, in some parts of the Netherlands local signposting still takes the form of black letters and figures on a white ground. These will ultimately be replaced by the blue-and-white signs.
The type of road and the sort of number it has can sometimes tell a driver whether or not it has any link function. This kind of information is often lacking on lower-order roads.
In Amsterdam a new routeing system has been introduced which directs drivers from the ring roads to the city and vice versa. These routes are part of the main street network. The city is divided into districts and sub-districts numbered in a way that is derived from the postal code. The driver has to know the postal code of his destination and the urban route number,[3] as well as having an understanding of the system. However, street plans of the sub-district are shown on information boards by the roadside.
Although this system is not yet understood or used by many drivers, it seems not unlikely that people will become more familiar with it in time, and will thus start using it more. More recent town maps often have district, sub-district and any urban route numbers. The postal code itself is now second nature to most people, so that it is now quite easy to locate the sub-district of an address on the map and then find the right exit from the ring road and the right urban route. Several Dutch towns have now introduced the sub-district numbering system by the roadside.

Special routes have been designated for certain dangerous loads, and they are marked along the roadside. Holland has no route signs for particular categories of vehicles, such as lorrries.

3.3.5 Alternative route markings; static signs

There are places where a sign at a junction indicates both a motorway route and a non-motorway route. A decision should be taken as to whether to choose a two-route sign or whether only the route with the best 'objective function' should be marked. So far the choice in the Netherlands has always been for a single route, that being the most functional one. This is generally the motorway. In West Germany fixed and numbered detour signs placed at autobahn exits and along the neighbouring main roads indicate an alternative route which later returns to the autobahn. Local congestion on the autobahn can thus be bypassed.

3.3.6 Dynamic route indicators

This kind of systems has not been applied in the Netherlands, partly because the problems tend not to be particularly great and partly because there are few adequate alternative routes available. Exceptionally heavy peak loads only occur once or twice a year (Easter, Whitsun). This contrasts sharply with some other countries, where problems of overloading occur frequently during the holiday season and traffic jams can extend over hundreds of kilometres of road.
In France a relatively simple system is used to route holiday traffic along alternative routes, consisting of lower-order roads, whenever the main route is overloaded. Detecting and assessing the problem and bringing the system into operation are done chiefly by police on the spot. Green arrows indicate the alternative route with an explanatory text, and the route can be in operation for a period of several days. Local diversions around towns, for example, are indicated by yellow arrows, and here some use is also made of automatic detection. These alternative routes are also marked on special road maps, together with the peak dates (for a preventive effect). Experiences with this system have been encouraging, and it is said that both the number and the seriousness of traffic hold-ups have been reduced significantly.

West Germany has to contend with similar problems during the holiday period. However, Germany has a network of autobahns which allows the alternative route to be equivalent in quality, apart from the extra distance involved. The systems exployed are quite advanced: detection, assessment and initiation are all automatic, except in the case of information on the nature of a disruption (an accident, or road works). A computer model is used whereby a forecast of the traffic situation in the next half-hour is calculated. This is then used to work out the total travelling time, the risk of vehicles running into each other from behind, and fuel consumption. The 'objective functions' are then calculated for the various alternative routes and the route with the best result is then indicated.
This system is currently being evaluated. Initial results again sound encouraging as regards both the degree of compliance and travelling times and fuel savings.

The following problem is inherent in the preventive approach described above. For reasons of credibility the indicated alternative route must be at least as good as the main route. This means that a relatively high threshold value must be exceeded before the alternative is signposted, and this in turn means that it is very difficult to achieve an even distribution of traffic over the two routes.

3.3.7 Radio information

The Netherlands has been broadcasting traffic information for a number of years. The weakest link in the system is data collection, but at the same time not a great deal is known about road-users' familiarily with the road system, or what expectancy patterns should be taken into account. The reliability of radio traffic information in the Netherlands should be improved. It may also be desirable to give information on the cause and duration of unusual congestion. Care must be taken to ensure that reference is not made to places or landmarks not marked on road maps. Conversely, consideration should be given to the idea of erecting name signs at major reference points (e.g. the Hoevelaken and Oudenrijn motorway junctions). When there are a large number of hold-ups the bulletins can be quite long, and this

can be a problem for drivers. In West Germany each region is covered by its own transmitter. Receivers equipped with the ARI (Autofahrer Rundfunk Information = driver radio information) decoding system can automatically tune in to the right station for the area, and will automatically switch themselves on (or will override a station or tape already being listened to) when a traffic message is received. Since the reaction time for the whole system is quite long, broadcast traffic information is best suited to quite long disruptions. It can thus affect journey initiation, the choice of transport mode, and route selection.
Radio traffic information combined with an alternative route numbering system might be an efficient way of indicating alternatives.

3.3.8 Visual route information on screen

One of the technical possibilities is visual information on routes and any alternatives, which can be called up on a screen at will. Where congestion is occurring and for complicated routes around and in urban areas such a system offers useful additional information. Motorway restaurants, petrol stations and motels might be candidates for linking to a system of this kind.

3.3.9 Individual route information: ALI

For some years the West Germans have been experimenting with what is called the Autofahrer Leit- und Informationssystem (= driver route and information system). This extends over an autobahn network some 100 km in length, and 400 vehicles have been fitted with the special equipment needed.
The system consists of detectors in the road, roadside electronics, a computer in a central control room and a display and keypad in the car. The driver inputs his destination using the keypad. This information is then processed at the nearest roadside unit and at the control room. The display then gives route information at decision points along the route. This takes into account the traffic situation along the various possible routes. If there is a fault in the central computer, the information fed to the driver is based on the geographical situation and the destination only, i.e. the same information is given as that provided by the signposting along the route. This takes no account of traffic and weather conditions. The system also indicates the speed appropriate to the conditions.
This experiment has recently been terminated. Although the system works in the technical sense, further research is still needed into ways of rapidly, reliably and accurately detecting and assessing traffic and weather conditions, the degree of user acceptance, and the system's effect on road safety and its cost-effectiveness for both drivers and the authority responsible for roads and traffic management.

3.3.10 Individual route information: ARIADNE

Turning to the Netherlands, Delft University of Technology has developed an experimental system called ARIADNE (Automatic Route Indicator, Delft University, Netherlands), which is comparable to the ALI system. The destination, in the form of a postal code, is set in the vehicle by means of a keypad. All vehicles approaching a junction from a particular direction receive the same information from equipment placed at the roadside. The computer in the car then selects the relevant information, depending on the destination, and advises the driver by means of the display which direction he should take. The system takes

account of traffic conditions. Because information on destination and vehicle category is transmitted from the vehicle to the roadside equipment at various points on the road network, it is possible to make a forecast of the traffic density on that network.
Information on vehicle category is necessary because there are certain classes of vehicle which are unable or not permitted to use certain routes (vehicles carrying dangerous or high loads, or heavy lorries). It is a simpler system than ALI, since ARIADNE is mostly a one-way and ALI a two-way system.
The future role of one or other of these systems will depend largely on the savings that can be achieved compared with the level of investment that will be necessary.

3.4 Conclusions and recommendations

The present route information system is capable of improvement in various respects.
The various sources of information must be better attuned to one another, and distribution should be more even. A relatively large amount of prior knowledge is needed before signposting can be used effectively. The amount of information which drivers have to assimilate must be kept within realistic limits. This applies both to information to be assimilated before the journey and to information fed to drivers *en route*. As far as possible route information should not compete for the driver's attention with the information he needs to keep the vehicle on the road and to carry out manoeuvres.

The road maps currently available could be improved. Possible improvements include the systematic numbering of roads, the numbering and naming of motorway and other exits, mapping of alternative routes, the inclusion on maps of reference points used in broadcast traffic bulletins, and the addition of indexes of place names and important reference points or landmarks.

Signposting can be improved by attuning it to the functional classification of road networks, and by the numbering of exits coupled with a permanent system of alternative routes with roads numbered systematically.

The reliability of broadcast traffic information should be improved by better data collection.

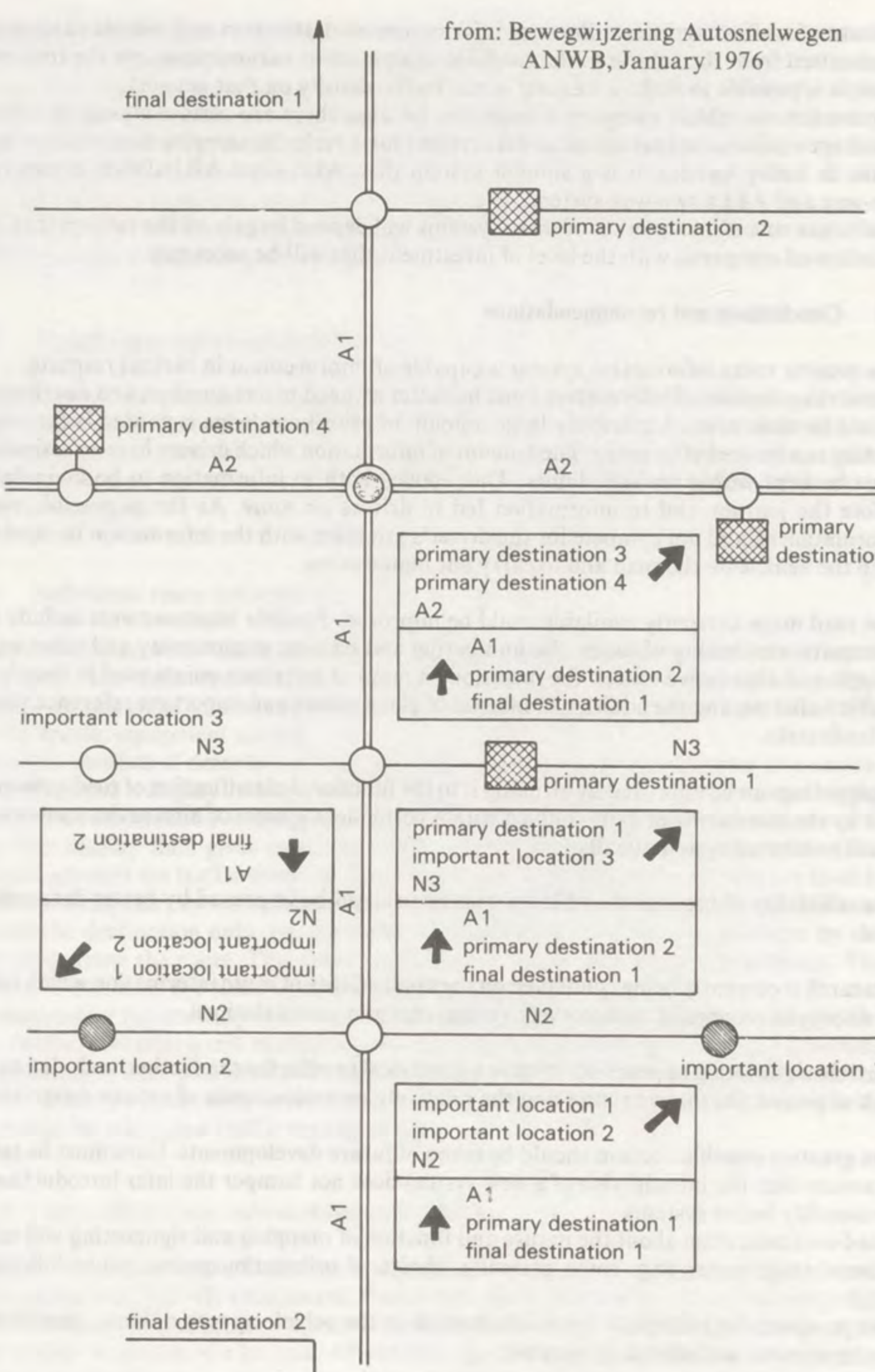
Research is currently being conducted on the applicability of route information which could be displayed on request at motorway restaurants and petrol stations.

Flexible signposting appears not to have a great deal to offer for the Netherlands due to the lack of proper alternative routes and the relatively rare occurrence of serious congestion.

The greatest possible account should be taken of future developments. Care must be taken to ensure that the introduction of a new system does not hamper the later introduction of foreseeably better systems.
Road-user education about the nature and function of mapping and signposting will make drivers' tasks easier (e.g. route planning, choice of orientation points, route following, etc.).
The prospects for individual route information in the vehicle appear dubious, considering the equipment needed and its expense.

For further reading see: [65-82]

from: Bewegwijzering Autosnelwegen
ANWB, January 1976



Criteria for place names. Through traffic: final destination + first primary destination; traffic leaving motorway: two important locations on either side of motorway. Where motorways cross: two primary destinations. At the crossing of A1 and N2, 'important location 1' is the exit name. To avoid misunderstanding it should be noted that the diagram does not show the actual layout of motorway signs.

Notes

1. 85% seems to be an appropriate norm.
2. If it is concluded that this is not the case, the road-user must be better educated. One may legitimately ask who is to draw the conclusion. It is generally the designer who makes a judgment, and he is not commonly inclined to look for the fault in himself.
3. If the only information a driver has is a street name, he can look it up in the street index to see in which district and sub-district it is, and can thus still reach his destination via an urban route.

4. The parliamentary data processing centre

by Ina Breman

4.1 Description of the system

4.1.1 Origins and purposes of PARAC

The Parliamentary Data Processing Centre in The Hague (Parlementair Automatiseringscentrum, known as PARAC) was established in 1976 as a working party with the task of examining ways of applying modern technology to the processing and accessing of information relating to the working of parliament. From the very outset the emphasis was on the problems associated with supplying members of parliament and their assistants with documentary information.
During the initial study period a survey was conducted among MPs, parliamentary party workers and personal assistants to establish requirements within parliament as regards the supply of documentary information. This survey, which was conducted by interview, was combined with a further survey of all those parliamentary offices and services which provide information in any form whatever. The importance of information in the work of MPs became abundantly clear. However, the survey also revealed two main problem areas.
- The fragmentation of the dissemination of information within parliament: the same information is made accessible in several different departments.
- The growing flood of documents published all over the world. In parliament itself the amount of information produced is growing: during the past 25 years the number of pages of proceedings has increased from 2,800 to 6,250 annually, the number of written questions to ministers from 200 to 1,800 annually.

Members of parliament are no more able than, say, scientists to keep up with the growing stream of documents and to assimilate all the information contained in them. The report of the Third Parliamentary and Scientific Conference [83] describes how the increasing activities of the government and the increasingly specialised machinery of government in the complex modern state have resulted in a shift of power between government and parliament, to the detriment of the latter. The decline in the authority of parliaments must be countered by enabling them to function independently of the executive authority. An up-to-date information system is one such means.

However, even the documentary information services are wrestling with the growing flood of documents. Classical methods, such as card indexes, are proving less adequate every day to cope with the growing demand for information. Soon after computers became available they were put to work compiling indexes and producing catalogue fiches. This did not remove the disadvantages of the classical system, however, the chief problem being the small number of entry points and the limited capacity for handling combinations of questions. It is only the latest generation of computers that have proved capable of coping with these tasks. They use complicated programs to find every word in a text, and they are also capable of applying a simple logic to combine different words. This development has been matched by the development of increasingly large computer memories, so that it is now possible to store vast quantities of documentary information and to subject it to highly specific searches. This form of documentary information provision was first used in the field of high technology (by NASA and the European Space Agency), soon followed by chemistry and atomic physics. There are now some hundreds of documentary data bases in almost every area of science [83].

This knowledge, combined with the experiences of other organisations (including government ministries in The Hague and parliaments in other countries) which already had computerised documentary information systems, enabled parliament to set up what was known as the 'automation plan for parliamentary information supply' [84].

The plan was approved by the Second Chamber at its plenary meeting of 27 June 1978, and by the First Chamber on 4 July. This decision led to the establishment of PARAC on a permanent basis. One view expressed during the debate in the Second Chamber was that, because of the high costs involved, the proposed system should be accessible not only to parliament but also to other interested parties, notably the subscribers to printed parliamentary matter.

4.1.2 Applications

The information used by parliament falls into two distinct categories: parliamentary information (statutes, parliamentary papers and the debates on them, questions in the chamber, etc.) and information drawn from other sources – books, periodicals and newspapers. To make these two categories of information accessible the following systems have been designed.

Parliamentary information

- The statute system, for accessing statutes and statutory orders.
- The parliamentary paper system, for the cataloguing, indexing and accessing of parliamentary papers.
- The proceedings system, for accessing the proceedings of parliament.
- The parliamentary questions system, for cataloguing, indexing and accessing written and other questions in parliament.

Bibliographical information

- The library system, for cataloguing the books in the libraries of the two chambers.
- The periodicals documentation system, for cataloguing and indexing periodical literature.
- The press documentation system, for cataloguing and indexing newspapers and news magazines.

When these information systems were set up it was assumed that documentation relating specifically to the Dutch parliament, which was often produced by parliament itself, could not be obtained from elsewhere. The computerisation plan therefore acted on the assumption that parliament itself would have to set up its own documentary information system, which would have the following features.

- Computers for the storage and management of the various collections of information and for accessing those systems through visual display units (VDUs). The selected structure permits the use of standardised computer programs which are used elsewhere in the Netherlands (including the documentation services of government departments) and abroad.
- Standardisation of indexing, to enable documents to be found by accessing a thesaurus. A thesaurus is a standardised list of words, isolated from the language. Relations are inserted between the words, indicating:
  - higher (broader) and lower (narrower) concepts;
  - synonyms;
  - conceptual relationships.

4.1.3 Theoretical background

In order to use a documentary system to answer questions about the contents of a document it is important to know how the system is structured. If you go to the public library the first thing you have to do is find out how the books are arranged on the shelves. This applies to an even greater degree in the case of computer systems, because the computer makes a literal comparison of the content of the question (the words) with the words in the document.
Computerised documentation systems use the following methods (and some hybrid methods) of storing documents.

- The complete text of the document is stored in the computer. The word in the question must then occur in the document. The disadvantage is that one is rarely familiar with the document's vocabulary (e.g. synonyms, orthographies, endings). The advantage is that the document needs no prior processing.
- A number of subject headings, defining the most important points in the content of the document, are stored in the computer. They may take various forms; most commonly they are either codes (numerals and/or letters) or words from a standardised list (thesaurus), i.e. keywords or descriptors. The chief characteristic of systems of this kind, however, is that they do not actually contain the original documents but only provide references to them. The question to be put to the computer must therefore be formulated using the codes or keywords used in the system. This means that there is no problem of synonyms, deviant orthographies etc. On the other hand when the system is compiled people have to carry out the intellectual work of interpreting and abstracting from the documents. (For a detailed analysis of these problems see [85].)

The system chosen for the parliamentary information system in The Hague is a hybrid of these two: a moderately detailed indexing system augmented by text, designed to achieve a golden mean between input processing (and cost) and the quality of the output.
The following information is recorded for each document.

- Identifying data, e.g. title, author/speaker, date. These data can be searched for and are mainly important in combined and administrative questions. If data are to be distinguished their structure must be recognisable to the computer. These data are taken straight from the document concerned.

- The text, or an abstract from it.
  In some cases the vocabulary of the text is limited (e.g. statutes) and it may be advantageous, for detailed questions and interpretation of the answers, to store the complete text in the computer. This is the policy adopted for statutes and questions. An abstract is included in the parliamentary papers, periodicals and press documentation systems.

- Accessing data.
  Accessing is by keyword or descriptor using a thesaurus. It was decided not to use a coded classification system because codes are less user-friendly than words when used on a VDU.

4.1.4 Technical structure

It was decided to adopt a dispersed structure: the documentary data files are stored in the central IBM 3081 computer at the government computer centre in Apeldoorn. The VDUs in and around the parliament building (about thirty in all) are linked to the central computer through a minicomputer (an IBM 8100).
Dialogue with the computer uses the STAIRS/TLS suite of programs developed by IBM, which allows the combination of free text and thesaurus-oriented search strategies.
Formulating a question entails inputting a number of search features (i.e. words which may be expected to occur in the data file) linked by various logical connectors, the best known of which are AND, OR and NOT.
In answer to the question the computer produces the number of documents it has found. This gives the questioner an opportunity of amending the question, since the number found may be very high (where an OR relation occurs in the question) or very low or even zero (where an AND or NOT relation has been used). If the number of documents found seems reasonable, the computer is then instructed to send the document data to the terminal and possibly also to the printer.

4.2 Overview of users

4.2.1 Parliamentary users

The departments of the First and Second Chambers which are concerned with documentation, and the offices which administrate sessions and meetings of parliament (the 'Griffies'), all have VDUs.
Since the terminals are connected to the government computing centre by a permanent link, and since the centre charges by the number of transactions (i.e. there is no charge if a terminal is switched on but not being used), the VDUs in most departments are left on all day. The advantage is that if there is a question it is not necessary to go through the starting-up procedure.
In the Second Chamber, in particular, the data stored in the computer are not available in conventional systems, so the staff in the departments have to use the terminals when answering questions. They are therefore used fairly intensively, especially on days when the chamber is sitting and there are a lot of questions. In the department dealing with questions on parliamentary material there is a relay system whereby one member of staff is always available to answer questions using a terminal which is switched on all the time.

4.2.2 External users

Outside parliament, too, there is an interest in the information stored in the computer by the chamber. The largest user outside parliament is the government information service (Rijksvoorlichtingsdienst, RVD). The RVD, however, is in rather a special position, for it works together with the Second Chamber in providing input for the press documentation data base. Moreover the terminals at the RVD are also linked to the government computing centre via the PARAC minicomputer, so that for users there the accessibility of data is the same as for internal users.

For other users outside parliament (at present there are 50) the parliamentary data are only part of the total information available. The majority of external links are with ministerial departments: others include universities, organisations such as the Socio-Economic Council, and the Federation of Municipalities in the Netherlands. Here the frequency of use is appreciably lower – about two or three times a week on average.
Some external users already had lines to the computing centre, but most have a dial-up connection. As a result, every time they wish to put a question they have to establish the connection and then go through the initial procedure. However, this is common practice in the documentary field, since it enables data bases all over the world to be accessed with relatively cheap equipment.

4.3 Experience of users

In view of the short time that PARAC has been in operation one has to be cautious in evaluating it. Particularly in the transitional period, when the switch was being made from the old system to the computerised system, it was necessary to consult both. This was unavoidable, however unpleasant and confusing for the user, and the fact that the new system had not yet been perfected made many users rather sceptical during the starting up period. Since then interest in the system has increased sharply. It should also be borne in mind that PARAC is not the only source of information available to members of parliament.

The experiences of users can be broken down into a number of areas:
– operating the terminal;
– using (or 'operating') the program;
– formulating questions;
– evaluating the answers.
Generally speaking, terminal operation has presented no problems for the majority of users. Even those with no previous experience of terminals and no knowledge of computer systems become familiar with the working of the PARAC system within an hour. As regards the other three user aspects there are discernible differences between users who have and have not had a training in documentary research.

4.3.1 Experience of users with training in documentation

The majority of users with some training in documentation are familiar with one important aspect of computerised documentation, namely the translation of questions into search commands for the computer. Even in conventional documentation systems (generally using card indexes) the question has to be translated, in this case into the descriptors used on cards or fiches. However, compared with the card-index system the computer makes greater demands on accuracy, since the orthography of a concept being asked for has to coincide with that used in the file to be consulted. This requires a higher level of discipline from staff at both input and retrieval stages. Against this, however, the combination of concepts by an AND, OR or NOT relation is extremely simple with the computer and extremely cumbersome with a card-index system. Answering a question about A and B and C only needs one question to be typed into the computer, but with a card system it is necessary to compare three piles of cards. This means that it is now possible to answer questions that could not be answered using the conventional system.

There are five frequently used commands, such as SEARCH, BROWSE etc. (or their Dutch equivalents), with about ten sub-commands, e.g. to instruct the computer to skip certain documents while browsing, and a further ten less common commands, e.g. to sort and print long lists with the accompanying sub-commands.
However, it turns out that the number of options is so large and that their frequency of use is sometimes so low that few people are able to exploit all the finer points. Moreover some options, such as sorting, or the use of larger than or smaller than, require some understanding of the working of the programs when questions are being formulated. This does not make matters any simpler for some users. Efforts are being made within parliament to ensure that all personnel of the documentary services learn all the ins and outs of the STAIRS software.

In some cases it was decided to store the complete text in the computer. This applied to written parliamentary questions and motions (because these are always short documents which do not lend themselves to abstracting), and extracts from statutes (because only the actual text as it stands has any importance). This means that the questioner no longer needs to look up the original document.
Since the user with documentary training is generally acting as an intermediary, he will generally make a hard copy for the person who is ultimately going to use the information retrieved. Hard copy (i.e. printed on paper rather than on the screen) is preferred by final users because they can take it away and study it at leisure.
Where data bases are being consulted on behalf of a third party it is important for the intermediary to understand fully exactly what the questioner means, and how much information he or she expects, e.g. all there is on a particular subject or only a number of documents for purposes of orientation on a wider subject. This can only work well if there is communication between questioner and intermediary with an opportunity for feedback. This can sometimes be a problem with busy people like MPs.

4.3.2 Experience of users without training in documentation

Users in the parliament building who have no documentary training are the staff in the parliamentary office and the personal assistants to MPs. There are also some users untrained in documentation outside parliament: these are generally office staff.
All these users are less familiar with translating questions into a fixed vocabulary of keywords, and it is not particularly surprising to find that they make virtually no use of the thesaurus facility. To ask a question the user has to enter the word or combination of words in the question. The answer expected from the computer is the document one is looking for, and any other answer is felt to be an annoyance, the computer often getting the blame. Again, it is not very surprising that such users rarely carry out what is called a search strategy, in which a number of questions are put in dialogue, each one referring back to earlier questions.
It is not long before users in this category run across problems with documentary programs. The program always answers the question as put to it, and never comes back with 'that is a silly question; you should rephrase it thus: . . .' In particular, it is not uncommon, when the computer produces a zero answer, for the user to conclude (usually prematurely) that the file is incomplete, whereas in fact the question as asked was incorrect or the document

sought does not exist at all.
Users without training in documentation, like those who do have some documentary background, tend not to be able to make use of the finer points of the program. One gets the impression that being able to use all the options is a function of the user's attitude towards new developments rather than of his or her experience with documentation systems.

4.3.3 Training courses

The above aspects of using the system come to light clearly enough when staff are trained. An attempt has been made to write a clear user manual setting out the content of the data files in detail. One of the factors in writing a manual for users of STAIRS, however, is that it must be suitable for both the occasional and the regular user. It looks as though this will ultimately result in two manuals, one concise version and one full version. During training, future users are given as many opportunities as possible to familiarise themselves with the process of answering questions using a VDU. In particular, an attempt is made to accustom people to the possibilities of building up a dialogue: asking questions step by step and modifying them in response to the answers.

4.4 Search systems

There are various search systems or strategies for looking for information in information systems. The main forms are tree structures and keyword-driven systems. Menus are explicit tree structures; other tree structures are somewhat less obvious (if you select page 69453 in a viewdata system by simply keying in the number, you are implicity choosing '6', '9', '4', '5' and '3'). Keyword structures analyse inputs and convert them into search or jump commands. A menu offers the user a list of search options (inputs) to choose from.

The PARAC system is an example of a system with a keyword search structure. Viewdata is a classic example of a system with a tree search structure.

The search structure built into a system determines the path that the user must follow to arrive at the information he needs to solve his problem. Ideally, then, this structure would automatically lead the user to the best possible path. Where this does not happen the user will be required to do some more interpreting. A tree structure with menus is easier to use than accessing a data base with keywords, because the menu points out the various avenues down which the search may be pursued. However, it is less suited to looking for specific documents: once the wrong turning has been taken within the structure the user has to go all the way back in order to try and find the right path. This is why, in an enviroment such as a library, where a wide variety of questions are asked on a range of subjects, information retrieval using keywords, with its ability to search through each concept direct, is more appealing. A keyword/command-language structure usually demands more cognitive effort than a tree structure, and in that respect may be regarded as less user-friendly, particularly for less experienced or more occasional users. Often, however, it will be much more efficient; it needs fewer steps and produces fewer 'misses'. In other words the chance of finding what one wants is greater, so that less time is lost and less irritation caused. This would appear to be a perfect example of an aspect whose degree of user affinity depends on a large number of factors, including:
- the user's experience;
- the user's intention ('browsing' versus purposeful searching);
- whether or not it is certain that the search item is actually present;
- the degree to which the user knows what he is looking for;

- the flexibility of the system;
- the intrinsic structure of the information through which the search is being conducted.

4.5 Technical user affinity

In addition to general user-affinity aspects, such as continuous system availability and short response times, special attention was paid to the following points when PARAC was set up.

- The information on the screen had to be legible, i.e. it had to use capitals and lower-case letters and the largest possible character set, so that printouts would at least approach the legibility of letterpress.
- The information had to be comprehensible, i.e. there had to be clear indications of the document title, date, file number etc.
- It had to be obvious why information was appearing on the screen, i.e. the word being sought had to be highlighted in the text.

4.6 Future developments

In the near future the system will be developed in two directions.

1. Files:
   It will be necessary to take a critical look at the contents of files filled in parliament itself. The intention is to store every document whose contents are of interest and to make it accessible by the use of keywords. In the case of some documents concerning the budget this entails a vast amount of work, since they run to over a hundred pages. This raises the question of whether an efficient retrieval result might not be achieved by storing only parts of the complete text in the computer. Not all the information needed by MPs is stored in the computer by parliament itself. Scientific and scholarly publications are only included if they have a direct relevance, and for other information the system relies on documentary literature files compiled by third parties. However, consulting such files is no simple matter, since there is little standardisation. For example, every file has its own document structure, and what one file might call a keyword another might call a descriptor or descr.
   Nor is the software used always the same. STAIRS is only one of many possible information retrieval programs, each of which has its own functions and commands. In Europe efforts are being made to produce a standard retrieval language (Common Command Language) but this is proving slow to get off the ground. Searching through external data files and data bases will therefore continue to be done by users with documentary experience, who will be given training for each data base.

2. Dialogue:
   The request that unattended terminals be installed, i.e. VDUs which do not have an operator continuously present, entails the need for simpler dialogue. At present, dialogue in Dutch is being considered. In particular this would make error messages clearer. These terminals will not be capable of using all the STAIRS functions.
   Work is also progressing on a skeleton command set which would offer only the most important functions, such as searching and browsing through the result.

4.7 Conclusion

The documentary information system used by parliament in The Hague, like all information retrieval systems, makes an initial impression of user-friendliness. It is possible to type in a word (in this case in Dutch) and the computer will produce an answer. If one goes into the available options a little more closely, though, one discovers a number of problems with operating the system. The chief difficulties for the user are:
- translating the question into the terminology used by the data file;
- the inability of the software to improve the content of the question asked.

For further reading see: [86-87]

5. The BAZIS hospital information system

by F.A. Leguit

5.1 Introduction

It is not surprising that hospitals have a particular and increasing need of an integrated information system. Shorter durations of stay, increasing numbers of out-patient visits, the concentration of hospital activities in peripheral departments (such as radiology, physiotherapy and the laboratories) and centralised services (hotel services, administration, etc.), and the increase in the number of medical specialisms make high demands on the organisation and internal communications of a hospital.
In addition to supporting communication, though, a hospital information system has two other purposes: more efficient use of the limited funds available to the health services and a qualitative improvement in services to the patient. In the case of teaching hospitals it can also be of assistance in research projects and can facilitate access to information for teaching purposes.

The processing of information by computer has been going on in hospitals since the 1960s, in chemical laboratories (to keep up with the progressive automation of the work done there) and, to a very limited degree, in the areas of registration and administration. Data processing systems were developed completely autonomously by and in the departments concerned, a fact reflected in the absence of a central store of information (i.e. a data bank), which meant that the exchange of information between those using it still relied on classical methods.
In 1972 the University Hospital in Leiden started an experiment with a hospital information system (HIS) for the Netherlands Organisation for Information Policy (NOBIN). The full-scale experiment was designed to establish, with due reference to developments abroad, whether the development of such a system was technically feasible and organisationally desirable in the Netherlands [88]. The object of the exercise was not, therefore, to develop a complete and transferable system. The extent to which the original objective (and some new ones) was met was reported in an evaluation carried out in 1977-8 by an external advisory agency [89].

Further development is currently under way in the framework of a collaborative association comprising the university hospitals of Groningen, Utrecht, Amsterdam (both University of Amsterdam and Free University), Leiden and Rotterdam and the collaborative association of general hospitals in the Hague and Tilburg regions, the whole operation being known as BAZIS (ZIS = Ziekenhuis Informatie Systeem = HIS). Such a large supporting structure, embracing 15% of all hospital beds in the Netherlands, is necessary for a major development of this kind, since it concerns a single integrated information system characterised by a single central data bank and a single network of terminals in which a large number of applications have been or are still to be implemented, in virtually every area of hospital operation: catering, admission planning, in-patient location registration, appointment scheduling, operations registration, diagnosis registration, laboratory applications in such areas as analysis, haematology, bacteriology and pathology, and administrative areas such as personnel information, accounts receivable, creditors, invoicing, general ledger and inventory, technical services and stock control.

5.2 User affinity: some preconditions

It is a feature of the system that it must be operational in an organisation run on a continuous basis. From this it followed that it was necessary to give high priority to system availability from the start. As a result, every participant hospital has every major item of hardware duplicated (central processor, disks and printer) and its own computing centre. Availability and technical reliability of 99.5% for seven days a week, 24 hours a day is thus possible. As, indeed, it must be.

There are also a number of other requirements which have to be met before the user can sit down at his terminal. For example, he has to be able to rely on the data fed into the system being stored safely. In the event of a fault it must be possible to recover lost data. This imposes a major demand on the operation and security of the central hardware and the associated procedures in the computing centres, but the control system must also have facilities to signal faults and errors and to provide support in the recovery of data.

It must be easy for authorised users to get at and into the system. At Leiden, for example, where some 1,740 users have access to the system, there are now 270 terminals, and more will probably be added in the future.

The following is a rough breakdown of present users in Leiden.

in-patient/out-patient departments	1,000
administration	200
hotel services (catering, portering etc.)	65
laboratories	175
other central services	300

Quite another aspect is how the actual users react to the software. User acceptance has been the chief criterion in the development of new applications. It does not apply only to a specific part of the system but to the system as a whole, and is largely determined by the amount and form of the support that the system offers the user in his day-to-day work. Users have been involved in the development work from the outset.

One problem yet to be solved is that people's capacity to form a mental image of what has been specified and agreed for development often falls short of allowing them to project it into the situation of their own organisation in order to see whether it will meet requirements. (This applies to almost every complex development in information science, not just the HIS). If anything, this is made even more difficult by the fact that part of the application, namely the results, may relate to areas outside the user's own day-to-day experience. The reason for this is that in an integrated system data are used for more than one purpose. For example, transferring a patient from one ward to another produces information for the in-patient location registration system but also for the parts of the main system

that keep track of production statistics and the financial side.
This is a point that receives continuous attention in the development of the HIS, bearing in mind the magnitude of the collaborative effort (the hospitals concerned employ some 20,000 – 25,000 people). The degree of acceptance is largely determined not only by the facilities offered but also by the failings of an application, and subsequent modifications are always more difficult. Efficiently organised development work is therefore a prime requirement.

5.3 The system in use: a hypothetical case

To illustrate the HIS in use, let us see what happens to a hypothetical patient, Mr T.G. Lucassen of Loowoude who, on his way to the post office, slips on a banana skin and realises to this horror that he has probably broken his leg.

A On arrival at the hospital he is documented, a process which he can follow on a monitor from his wheelchair.

B When he arrives in the ward his location details (name of ward, time of arrival, etc.) are entered into the system by a nurse. This automatically warns the kitchens that they have a new customer, and tells Medical Records that authorisation for admission must be sought from Lucassen's insurance company, as well as alerting external services (including his GP and the chaplain or other spiritual counsellor) to his arrival.

C Meal details are entered in the kitchens, or by a dietician on the ward, so that the right meal can be prepared.

D Medical Records ensures that authorisation is granted by the insurance company (a form of guarantee) and enters the authorisation details.

E The doctor in charge of Lucassen's treatment can ask for a run-down of all Lucassen's details as recorded in the system (results of laboratory tests, discharge diagnoses, ECGs etc.).

F X-ray photographs are taken in Radiology and the system can be asked whether X-rays have been taken of Lucassen before, and if so how many and when.

G Requests for laboratory tests are entered, and when the test results are ready they are printed out on the ward printer. If at any time Lucassen is moved to another ward, all his details, and his meals, are automatically sent on to the new ward.

H Lucassen is operated on, and some of the details of the operation (e.g. surgeon, any diagnostic surgery) are entered in the Surgical office. After his operation Lucassen is hooked up to a monitor in Post-Operative Care (computer applications of this kind will be disregarded in this case history).

I Some time later Lucassen is better and can go home. Medical Records enter the discharge diagnosis from a discharge note.

J All the work entered, photos, laboratories, treatment days, etc. are collated by the system, production surveys are produced, and chargeable items are invoiced.

K These items are entered in the Ledger and Accounts Receivable systems, where they are then handled by the hospital administration.

What is typical about this example is not the number of transactions involved but the fact that so many people in the hospital are involved with the information system in the course of their work with Lucassen. But the differences in the ways they use the system are enormous, not only within particular departments but also between departments.

5.4 Aspects of using the system

Let us now look more closely at particular aspects of user affinity or user non-affinity.

Whereas patient documentation – A – used to be a centralised function, it is now far more decentralised. The implication of this is that whereas patient documentation used to be a user's routine primary task, it is now only a small part of his function. In a decentralised system, moreover, there is a new factor, namely that the documentation function must be fitted into the whole range of activities. At stage F, in the radiology department, the user will not only have to ask for documentation details but will also require and/or enter details specifically relevant to Radiology. In other words, one of the consequences of decentralisation is that the same function will have to be performed in several different procedures. This makes new demands of the development of the product: it will have to have more facets.

Besides the person at the terminal, Lucassen himself is a user of the system at stage A, since he is asked to check the details as they are entered. This means that the dialogue on the terminal must be easy to follow without too much effort, even for Lucassen. Furthermore, the fact that the patient is able to follow the process creates a sense of openness and reduces the air of mystery surrounding the terminal.
Where in-patient location data are documented – stage B – we are at once dealing with a large group of users: the nursing staff, who are fairly unused to keyboards, let alone computer terminals. Equipment of this kind has never been a traditional feature of their job, and starting a system in these circumstances often means that training has to be given in keyboard skills. One reason for using this kind of terminal in the HIS is the cost price, which is relatively low and thus enables us to have a better spread of terminals.
Since using a computer is not routine to nurses, questions are asked and entered in uncoded and complete form. This contrasts with the user at stage G, who keys in lab requests in large numbers every day: here input and output are highly compressed.
In either case, however, data have to be checked immediately after entry so that corrections can be made at once. The implementation of an in-patient location system is thus not usually completed in a single day, and this in turn means that the system has to be able to function in a transitional situation. Very often Medical Records will enter this information centrally, using the original ward report of patients in the ward and discharged (Medical Records staff have always been familiar with keyboards and routine inputs), after which documentation is gradually passed over to the wards. In this case, of course, the form of dialogue chosen, since it is all in one program, will have to be comprehensible to both user groups.

Another major difference between departments concerns the person to take action. For example, one part of the hospital may be in the habit of having the bed occupancy lists made up by the computing centre in the evening, but elsewhere the ward sister may ask for them through the terminal.
The nursing lists will be essentially the same, but if they are produced by the computing centre as part of the evening routine there will be a need to put up with a certain amount of automatism, though some variables, such as the date, will not need to be entered. By contrast, where the lists are produced on a decentralised basis, a deliberate choice will have to be made as to which list must be compiled for which date. In other words, it will be a tailored dialogue at the terminal, as opposed to no dialogue at all.

The request for lab tests in Lucassen's case – G – will be entered on a terminal in the laboratory. Again, the user will want a compact, fast dialogue. Fast in this context means that the smallest possible amount of data has to be entered, and that response is quick enough to keep pace with the user's own speed of work. Working lists will then be drawn up for the laboratory technicians, and the order on the list must accord with the way the lab works. The program for inputting the results of 'manual' decisions must also follow the order on this list. Here the output, paper, must tally with the question order for inputting the result. Moreover, when the result is entered there must be feedback from the system such that abnormal values are detected and signalled, so that any typing errors can be corrected immediately.

Recording details of surgical operations – stage H – and the discharge diagnoses – I – entails various data, such as the diagnosis code, being input in coded form, since there is no 'automatic' encoder. After the code is typed in, its definition appears on the screen so that it can be checked. Codes remain – except where they consist solely of a very short list of mnemonics – something of a user-unfriendly affair. The advantage of a computerised system is that there is an 'echo'.

In addition to main diagnoses, subsidiary diagnoses with a probability factor may be entered, perhaps with a line of ordinary text. The point about the free text is an important one, since it can break through the rigid character of the system and enable shades of opinion and description to be included which will assist in the correct recording and subsequent interpretation of reality.

As regards further processing in the financial channels (J and K) it is important that the information already known from the applications already mentioned is actually used. It does nothing for a user's motivation if he knows that the information he is entering is in essence already available. Steps have to be taken to ensure that no new financial circuit is created alongside the medical information system. Data for administrative purposes should be drawn from the same circuit.
Since the hospital administration uses data recorded by others it must be able to call up a summary of, say, a patient's admission without too much trouble. Here it is important that without having to interrupt the working process the user should be able to switch from general information to details, though data not having anything to do with finance then have to be suppressed. Facilities of this kind add greatly to the system's user affinity. This final financial processing terminates our interest in Lucassen.

5.5 Evaluation

The evaluation of the system in 1977-8 devoted considerable attention to the question of user acceptance [90]. At that time it looked as if the only way to acquire insight into the degree of acceptance and appreciation of the system was to conduct an extensive survey using questionnaires and involving the direct users. Though the result was extremely encouraging, there is certainly room for a critical note here: how were users supposed to know whether the system was or was not user-friendly? Since they were unfamiliar with any other system, what did they have to compare it with? Even so, the system was accepted, and there are plenty of examples of systems of this kind which, if only because of their response time and reliability, have failed to make it in hospitals.

5.6 Conclusion

The continuing development and introduction of the BAZIS system is inspiring all those concerned to come up with new ideas and implementations, some of them relating to user affinity. Outside developments and the publicity given to other possibilities are both extremely influential. The user affinity aspect is bound to continue to have a floating value affected largely by technical possibilities and, particularly, impossibilities. Users will still to some extent have to adapt themselves to the technology and the method, just as writing had to adapt from the clay tablet to the sheet of vellum.

6. The CORDA flight reservation system

by A.C.M. Mosseveld

6.1 Description

6.1.1 Origins

Like any other business marketing a product, an airline must have some form of stock control and order administration system. A flight reservation system is such a system. Every airline has one and they are all more or less the same, though some are more modern than others. All of them, however, have evolved from a manual system which, briefly, works as follows.

Sales offices have all the information necessary to prepare a journey (timetables, prices, tickets, etc.). They also have details of seat availability. When a customer transaction is completed it is entered in a card index and the office reports the reservation (generally by telex) to the various stations from which the flight concerned will be controlled. They, in turn, record the details from the telex (the passenger's name, route and reservations office) in their own card system by flight number and date. Thus two registrations take place, one passenger-oriented and one flight-oriented (order and stock). Telex communications between reservations office and flight controlling station are conducted in a special airline code called AIRIMP (Airline Reservations Interline Message Procedure).

This method was used for many years, and it was adequate in an age when flying was still a relatively exclusive business. As traffic increased, however, it became clear that there were certain disadvantages.

By the end of the 1950s hundreds of thousands of telex messages were wandering over the globe, all of them needing processing by hand at all sorts of places. The result was a recurrent backlog of registration leading to corruption of data. It was fortunate that computers came along when they did. IBM and later UNIVAC introduced large computer systems, and to support their sales the manufacturers, in collaboration with a number of airlines, developed software packages which made it possible to computerise the entire flight reservation process. KLM computerised its reservations operation in 1969. The system used is called CORDA (Computerised Reservations Royal Dutch Airlines).

6.1.2 A brief description of the CORDA system

In hardware terms the CORDA system now consists of two IBM 3033 computers, one of which is used for reservations while the other has various functions. However, they are switched so that the second machine automatically takes over as soon as the first one has problems (this is known as 'hot standby'). External memory takes the form of tape units and disks.

Some 3,000 terminals and about 1,000 printers are linked to the system at locations all over the world. All the European countries (with the exception of the eastern bloc) are linked to CORDA, as are Canada, the United States, Mexico and the major countries of Central and South America and the Caribbean. There are also terminals and printers in Nigeria, Kenya, South Africa and Egypt, almost the whole of the Middle East, Pakistan, India, Thailand, Singapore, Indonesia, Hong Kong, the Philippines, Japan and Australia.

The links between the terminals and the central computer are by lines leased from national telecommunications networks or through SITA, an organisation set up by the airlines to provide them with communications links. This means that costs can be reduced because several SITA members can use one data line.

The software used falls into two categories: control and applications. Control programs enable the system to work. They take care of storing information and keep track of where it is stored. They govern the internal processes and warn the operator when something threatens to go wrong or when some action is required of him. Roughly speaking, control programs can be compared with those functions of the human brain that ensure that the body functions. If everything is all right the 'user' has nothing to do with them.
Control programs are specially designed to allow rapid dialogue between man and machine. At peak times they may process about 100 messages a second, and it is partly due to the CORDA control program (known as the Airline Control Program or ACP) that response times can be kept to 3 seconds or less in 90% of cases. Where communications are bad, at times of extremely high load or when long, complicated lists are asked for, response times may increase somewhat.

The end user, as observed, has nothing to do with the control program. His dialogue with CORDA is conducted through the medium of applications programs. These do all the jobs that used to be done manually. The system holds a multitude of files, each containing information which the user might need. Thus he can consult timetables for all scheduled flights. These are stored as 'city pairs': Amsterdam-London is a direct city pair and Frankfurt-Amsterdam-London is an indirect city pair. The system holds details of about 40,000 direct and 60,000 indirect city pairs, amounting altogether to some 250,000 route options. For most flights the system also keeps track of whether there are still seats free or not, and other information is also stored. Thus the terminal can be used to book flights with KLM or other airlines, as well as hotel rooms, car hire, etc. The system compiles its own record of passengers, updates the seating stock on KLM aircraft, and communicates sales and cancellations to other airlines where necessary. Other reservations are sent on to the hotels or tour operators concerned.

Communication between CORDA and other airlines is by telex using AIRIMP code. Dialogue between the terminal and CORDA is conducted in a special CORDA language, a mixture of AIRIMP and a cryptic form of English, which also enables the dialogue to be smooth and fast.

Both control and applications software are based on the original IBM PARS (Passenger Airline Reservation System) package. However, over the years the various airlines have spent hundreds of man-years extending and modifying the system, chiefly to improve internal processes, speed up the input of new timetables, perfect the techniques by which the computer 'reads' incoming telex messages, and make system answers clearer. KLM has also constructed a hotel reservations system which is built into CORDA, and there are internal connections to later developments like CODECO (Department Control) and fare quote and ticketing systems. At the same time CORDA has been modified for use by other airlines, called multihost partners, which use it as their own reservations systems with their own terminals, paying a fee per passenger. At the time of writing nine other airlines are linked to CORDA.

6.2 Users of CORDA

The users of CORDA (the people at the terminals) are a very heterogeneous group. In almost fifty countries CORDA terminals are in daily use by people of different national, linguistic and cultural backgrounds, yet the quality of operation varies hardly at all. This is probably because we try to attract employees of equivalent educational levels: a general secondary level of schooling and a reasonable knowledge of English are the basic requirements. At the same time the work, the training and the *modus operandi* are in principle the same for every CORDA operator.

The main element of the work is selling tickets over the counter or by telephone, and supplying information, for which CORDA is being used with increasing frequency. A Direct Reference System makes it possible to store a great deal of locally relevant information and display it as required. This saves time and effort looking through all sorts of books, leaflets and bulletins.

Training consists of preparatory written courses on the AIRIMP code and the principles underlying CORDA, after which employees receive hands-on training in Holland. This takes ten days, after which they can become more practised through using a training program built into CORDA which uses prompts to take the learner through the various transactions. This refresher course can be done back in the employee's own office. Keying in a simple code brings the first prompt up on the screen, placing the learner in a particular situation from which he is asked to take a particular course of action. In this he is guided by answers from the system. At the end of the transaction the system awards a score. The exercise can be repeated until the score reaches 100%.

On average it takes between six and eight weeks to train an employee to full competence on CORDA.

6.3 User affinity

Although user affinity is a subjective concept, it is still possible to think of various factors with which one might determine the user affinity or non-affinity of the CORDA system. They are:

a. availability
b. reliability
c. privacy
d. response times
e. simplicity in use
f. flexibility/adaptability

a. *Availability*

Availability is an extremely significant factor. A telephone sales employee spends the entire working day sitting at his terminal. If it is not working for one reason or another there is nothing useful he can do. He may be able to speak to customers and give them a certain amount of information from printed timetables, price lists etc., but he will be unable to do anything concrete, i.e. make reservations or cancellations or provide information on seat availability. The most he can do is make a note of the customer's requirements and ring him back when the system is available again.

The same applies, to a slightly lesser extent, to counter staff, who may be able to issue

tickets previously prepared, for example. However, they too will have to make a note of new reservations and changes until the system is ready again.
The non-availability of the system is not just a source of irritation to staff. It can also, if it persists for a long time or recurs with excessive frequency, damage the company's image and thus ultimately its turnover. Hence the very high standard required of availability.
Since the CORDA network covers virtually the entire globe (there is a time difference of 19 hours between the most westerly and the most easterly terminal) the central system must be operational almost 24 hours a day. The data network, too, receives special attention. For example, there are several different switching options so that faults in one part of the circuit can be circumvented (e.g. by switching from cable to satellite to microwave link, and so on).
The proper functioning of local hardware is also guaranteed as far as possible by strict maintenance, a certain level of redundancy in terminals, and linking terminals in various different clusters to a number of processors.

b. *Reliability*
As far as CORDA is concerned the concept of reliability can best be approached through the following questions.
1. Is the information supplied by CORDA always accurate and complete?
2. Are the data stored in CORDA so protected that they cannot be lost?

The answer to question 1 is no. It is impossible to achieve perfection, though it might fairly be said that CORDA's files are almost 100% reliable. This also applies to the timetables and seat availability figures available for KLM flights and flights by other airlines participating in CORDA, though the same cannot always be said of airlines not hooked up to CORDA.
Even so, CORDA does contain details of all scheduled flights througout the world. The source here is the Official Airline Guide of America (OAG), in which all airlines publish their timetables. KLM uses the base tape for this guide to feed CORDA. A new tape arrives once a fortnight, and any inaccuracies are due to timetable changes not yet published in the OAG. Seat availability changes for these flights are supplied direct by telex from the airlines concerned, but inevitably they cannot always be fully up to date.
Despite this, the situation is a great improvement on the days before computerisation, and compared with the vast amount of data now handled the system must be regarded as extremely reliable.
The data stored in CORDA are virtually 100% secure. All data and all input messages are stored on duplicated tapes, the two being kept in safes at geographically separate locations. On-line data can thus be recovered relatively easily in the event of a mishap.

c. *Privacy*
Privacy has a limited role in CORDA. There is privacy of reservations data between the affiliated travel agents, and between affiliated airlines (the multihost partners). In either case, this means that passenger details are available only to the organisation which originally entered them in CORDA, except that KLM employees have access to all passenger data supplied by affiliated travel agents. However, in the case of data provided by multihost partners they can only access information relating to flights controlled by KLM.

If there is a limited amount of privacy for data, the same does not apply to those who actually operate the system. Every CORDA employee must first identify himself or herself to the system by means of a unique password before being able to undertake action of any kind. All actions are logged with the employee's password and the time of the transaction.

This means that it is theoretically possible to monitor everyone, though this is never done on an individual basis because data of this kind are fairly meaningless when they refer to single individuals. We already know that one person is quicker with CORDA than another. Apart from that, few conclusions can be drawn from such data without a knowledge of the course of the conversation and other circumstances.
Nevertheless monitoring procedures are occasionally carried out for a certain period, but these refer to an arbitrary group of CORDA operators scattered all over the world, the purpose being to discover whether there are any particular recurrent errors. Information of this kind can help decide whether to make improvements to software routines or instructions. All employees are aware that their actions are logged and that monitoring is therefore possible.

d. *Response times*
The response time is an extremely important factor. Generally speaking, CORDA employees do their work in direct contact with the customer, and the response time must therefore be short enough not to disrupt the natural rhythm of the dialogue between employee and customer. It has also been shown that excessive response times arouse irritation in the operator because he feels hampered in the exercise of his function, and this has a direct backlash on the quality of the work. We have found that a response time of 3 seconds or less is short enough to obviate such symptoms. Hence the 3-second target for response times, which as already noted is achieved in 90% of cases. (See 1.2.)
Delays caused by asking for voluminous data never give rise to irritation because there is a readily apparent cause. Searching for three or four hundred names and sending them half-way round the world in ten seconds is still going to impress most people, and there is little that can be done about poor atmospheric conditions. System overload can sometimes be alleviated to some extent by fine tuning and adding extra external memory capacity.
There are no plans to reduce response times further. The expense would increase asymptotically without any measurable improvement in production or quality.

e. *Simplicity in use*
KLM was one of the first companies in Holland to use visual display terminals on a large scale. A great deal of attention has been paid to the ergonomic aspects of their use, as a result of which they are mounted on special tables and have separate keyboards attached only by a cable and hence moveable in relation to the screen. Screens are designed to be non-reflective and as far as possible are placed where no direct light falls on them. Lighting is controlled and operators' chairs are on castors and have adjustable height and backrests. By and large there are no complaints and operators can spend a full day working at their terminals.

Operating CORDA is quite a complicated job and cannot be done by a layman. As noted earlier, some six to eight weeks' training is necessary before competence with the system is achieved. However, practice nullifies the effect of the complicated language, and operators experience their work as no more stressful than any other.
The disadvantage of the complicated operation lies more in the costs incurred through the relatively long training period. The reason for the rather difficult operating language must be sought in the design of the software, which was intended solely to achieve rapid response times with the least possible load on the system. The result is that the operator has to use a low-level language (i.e. one close to the level of the machine and further away from his own language).
The language of CORDA is full of non-mnemonic codes and the answers provided by the system are frequently polyinterpretable. Something can be done about this by further

refinement of the validation software, and work is gradually progressing on this.
The system also has no help functions. Nor can it be called foolproof, though an untrained 'fool' would be unable to make a reservation using it. However, it remains possible to make an erroneous reservation by, say, entering the wrong date. There is no check on this, nor can there be.

f. *Flexibility/adaptability*
Due to the complicated structure of the CORDA software it is extremely resistant to change. Although the system can gradually be adapted to new requirements, it has to be said that CORDA is extremely user-unfriendly, and it may take months before a new change asked for by users can be implemented. Due to the basic design of the software this situation is unlikely to improve: a complete rewriting of the software would be necessary, something that can scarcely be expected to happen considering that the bill would run into millions and would bear no relation to the possible advantages.
This inflexibility makes CORDA difficult to adapt to other systems. If links are desired it will have to be the other systems that change. Either that, or front end computers will be needed.

6.4 Future developments

Although new facilities and functions are constantly being added to CORDA they have very little to do with user affinity. There are, however, some exceptions to this rule.

6.4.1 Viewdata links to CORDA

An experiment is currently under preparation to establish whether it is possible to circumvent CORDA's difficult operation by inserting a minicomputer between CORDA and the user in order to convert a user-friendly language into CORDA language and vice versa. It is hoped to use questions to guide the user to particular preformatted screens through which the desired information could be retrieved from CORDA. This would make CORDA accessible to novices.

6.4.2 Self-service

Various airlines and computer manufacturers are investigating ways of introducing a form of self-service for airline passengers. The idea is that sophisticated ticket machines linked to an airline's central reservations system would enable travellers to make their own reservations, buy their tickets and board the aircraft without the intervention of airline staff. Simplicity in use is naturally a prime consideration.
A number of computer manufacturers have already conducted in-depth behavioural studies to find out how such a machine should be designed in order to get people to use it. However, they are keeping quiet about the results of these investigations.
Practical applications would appear to be restricted to the United States, where the majority of flights do not involve potential problems like language differences and immigration checks. Nevertheless, experimental systems may be expected in various countries within the foreseeable future.

6.5 Conclusion

Viewed from the angle of the user (the person at the terminal) CORDA scores quite well on points such as availability, reliability and response time. Privacy plays only a limited role.

Operation of the system requires considerable training and the software is extremely inflexible and difficult to adapt to other systems. Yet everybody is reasonably satisfied, some sixteen million passengers are processed annually by the system and, with gradual modifications, it will continue to be useful for years to come.

For further reading see: [91–101]

7. Information systems in teaching

by M.B. Figee

7.1 Introduction

At the end of the 1960s most educational publishers were working with great enthusiasm on the 'audiovisualisation' of the teaching profession. Audio tapes and discs for teaching foreign languages, with of without accompanying film-strips or slides, transparencies for overhead projectors, super-8 cassette films and videotapes were all developed in the expectation that the dawning of the 1970s would see a great breakthrough in the media of teaching.
At the end of the seventies came the hangover: the expected return on investment had failed to materialise. Not only were the financial losses considerable, the urge to innovate had gone cold. Only a few more or less traditional media had become established. For the rest it could only be observed that the teaching profession was continuing to distance itself from the modern media at a time when technology was beginning to assume an increasingly important role in everyday life. The same could be said of education outside institutionalised teaching, in commerce and industry for example. The teacher with his chalk kept the upper hand.
What caused this reluctance in teaching and training? Was it simply unfamiliarity with the didactic potential offered by the media? Was it fear of the unknown, a sort of 'technophobia'? Was it an example of apathy from the teaching profession? Or can it all be traced back to the problem of finance?
Now that the possibilities of conveying information electronically have become almost limitless, the time has come to think about the fiascos of the recent and not-so-recent past. They have taught us, among other things, that it is mistaken to consider the evolution of media exclusively or chiefly from the angle of their technological potential.

The incentive to use particular media in education comes from various quarters and is in many cases not entirely (or entirely not) free of bias: the manufacturer of hardware, the software publisher, the enthusiastic teacher whose hobby is photography, the microcomputer hobbyist, the educational innovator, the school adviser and the professional media expert all have their own motives and arguments for getting teachers to use their media. In many cases the argument centres on the equipment.
At times a particular medium will be fashionable. There was a time, for example, when everyone had to have a language laboratory. Not uncommonly, though, it was not long before it was shut down again, either because of a change in staff, or because there was no suitable teaching method in which the use of a language laboratory was an integral component, or for some other reason.
Not uncommonly, too, particular conceptions of education are sold to the future users along with the media. This is what happens in the case of 'canned' information, i.e. when educahion is provided *by* media and not simply *with* media.

If one wishes to avoid purchasing equipment which will turn out to be unsuitable for its purpose, or the use of which creates more problems than it solves, it is a good idea for teachers to consider why the medium in question is being brought into the school or training programme in the first place. Here there are many arguments to be weighed, some of which will have to relate to the particular circumstances of a school (or whatever), e.g. the curriculum, the willingness of teachers to use new media in their teaching, how the building is equipped and laid out, the composition of the student body (e.g. whether more than one ethnic group has to be catered for), and so on.
The technological educational innovators – the hardware manufacturers and sofware houses – will have to arrive at a dialogue with the teaching profession in general in order to achieve problem-oriented development. There is no place in such a dialogue for such simplistic claims as '80% of all the knowledge we acquire reaches us through our eyes and hence through pictures'. (In this connection Prof. J.M. Peters remarks that we also use our eyes for reading, and for simply looking about us, but the words we read are not pictures, and looking at pictures is not the same as looking at reality itself. The conjunction of optical and acoustic impressions can sometimes be helpful, but in other cases it can also lead to confusion and interfere with the assimilation of knowledge [102].)

7.2 The didactic problem

In the 1960s a new phenomenon, programmed instruction, became popular. Programmed instruction is a tested, individually oriented form of teaching. When developing his programme the teaching material programmer brings in representatives of the target group and, by testing them, determines whether or not the programme leads to the precisely defined objective. The strength of programmed instruction lies in its similarity to the classroom dialogue and in its meticulous preparation.
As it was originally seen, programmed instruction meant an individual form of teaching in which the teaching material consisted of simple, short steps. At each step the student reacted actively by answering a question. He could then immediately compare his answer with the programmed correct answer. The steps were so small that students hardly ever made mistakes, and this, it was claimed, gave a sense of achievement which had a favourable effect on the learning process.
To avoid the possibility of students learning the programmed correct answer prematurely, all sorts of teaching machines were developed along with the programmes (which, incidentally, were suitable for use only with the machines on which they were developed).
When it became clear from experiments that none of the qualities originally attributed to programmed instruction was essential for success, the concept of programmed instruction became vaguer, definitions merely referring to the method of preparation or the nature of the result. Things no longer revolved around the teaching machines and programmes. The main point now was the didactic problem: what should who know and to what purpose, and how can it be taught?
It is these questions that must also be foremost in the choice of other, new media. It is on them that the choice of teaching method and learning activity must depend. The teaching and learning aids to be used must fit in with that choice.

7.3 Choosing a medium: no simple matter

Choosing the most suitable medium for a particular didactic purpose is no simple matter. When arriving at a choice one has to take a number of variables into consideration as well as the ultimate objective (see matrix). Generally one will arrive at a media mix consisting of the use of some or all of the following aids: books, maps, plates, the spoken word, wall

charts, slides, films, video, excursions, models, and so on.
Gerlach and Ely have drawn up a matrix of the variables to be taken into consideration in the making of the media choice [103]. The selection factors shown are the following.

Appropriateness	Is the medium able to complete the task defined?
Level of sophistication	Is the medium attuned to the students' level?
Cost	Is the cost appropriate to the benefit: the learning results?
Availability	Will the medium be available when it is needed?
Technical quality	Is the quality of the material acceptable? Is it legible, audible, visible?

The matrix also contains a number of objectives and media, of which the latter can be extended as desired. The point here is the principle of making connections between the various elements in the matrix.

	Real Things	Representations: Verbal	Representations: Graphic	Pictures: Still	Pictures: Motion	Audio Recordings	Programs	Simulations
SELECTION FACTORS								
Apropriateness								
Level of Sophistication								
Cost								
Availability								
Technical Quality								
OBJECTIVES								
To Identify								
To Name								
To Describe								
To Order								
To Construct								
To Display Attitudes								
To Perform Motor Skills								

These factors must be considered first if no barriers are present, then move to objectives below. If barriers are present ask if they can be eliminated so that selection can be based on objectives.

7.4 Teaching: a question of communication

Teaching is a matter of offering information and of assimilating information, and thus of communication.

The communication processes involved in teaching are rather special, since it is not merely a matter of information being proffered which may be accepted or rejected; the recipient is under some sort of obligation to assimilate the information and to master it to a level formulated in the definition of the objective.
The situation in which teaching generally takes place differs from the circumstances of other communication processes in one important respect. In the classroom the 'transmitter' of the information being communicated is not only present at all times, but is also continuously available to assist in the reception and assimilation of that information. All other teaching processes – correspondence courses, language lessons by radio, the Open University, as well as audiovisual teaching programmes – are substitutes, made necessary by circumstances, for the basic situation in which teacher and pupil are in direct dialogue with one another.
Now the media by which communication takes place in education not only make the processes of communication possible, they are also determinants of teaching and learning behaviour. In the case of face-to-face contact the process of transmission is by a natural channel. If an artificial channel has to be used, all sorts of technical apparatus has to be involved in the transmission of 'texts'. Media in the sense of means of transmission are secondary to media in the sense of means of formulation. Before anything can be transmitted along the technical lines of communication there has to be something to be transmitted: the information as formulated.

7.5 Fiascos in educational publishing

Contemplation of past failures only serves a useful purpose if it is done in the context of their causal connection with new strategies for the production of programmes and equipment.
This is clearly not the place to speak about or on behalf of educational publishing in general. Nevertheless, going by observations both in the Netherlands and elsewhere, it may be said that virtually every educational publisher has at some time or other had to pay not inconsiderable sums in tuition fees for the privilege of learning that the development of programmes has been too heavily concentrated on thoughts for the product rather than on a consideration of the needs of the market.
Multimedia teaching packages were developed both for traditional forms of education and for training courses within companies. They offered a form of pre-moulded education, but the developers were not in a position to take responsibility for the ultimate success or failure. It is a fact that there were few takers for those multimedia teaching packages which prescribed narrow bounds within which the learning approach and the teacher's teaching behaviour were constrained. Perhaps the few purchasers were only the 'real' innovators who react positively to almost every new development to come along. More than once, publishers fell into the trap of extrapolating the initial reactions of such innovators and translating them into print orders with which they later found themselves saddled.
More successful, in terms of sales, were the limited programmes which could be used flexibly and could serve as 'enrichment material' or 'fertiliser', though even they were never produced in large numbers. Media were used more intensively in Britain. This may have been due to the establishment of media centres in the major cities and in the regions, where teachers could receive training and advice. Companies in the United Kingdom have training boards which organise and monitor the statutory training programmes. Some of the cost of such programmes has to come out of wages. This too has had a stimulating effect on the development of 'training kits'. Then there are the Open University and the BBC, both actively furthering the use of media. There is no form of media usage which can be regarded as perfect, but the efforts of both these organisations do provide examples worthy of closer

and more intensive study. The BBC, for example, has introduced a computer for educational use which looks as though it may well become a success abroad as well as in the UK.
The media as sources of information were also reasonably well accepted in Holland as a means of bringing the outside world into the classroom or training group in the form of information about other countries and peoples, new technologies or methods, and so on.
Some fiascos, perhaps, can be explained in terms of technical imperfections in the means of transmission. There were times when the hardware let teachers and presenters down at the critical moment. Accidents could happen very easily. For example, a projector bulb went, and the only spare was handled while it was being put in and burnt through almost immediately. Where such incidents took place at well-attended meetings the repercussions were wide.
Equipment has been greatly improved since then, partly due to the advent of microelectronics. It is uncommon, today, for a video recorder to go wrong and produce nothing but 'snow' just because it has been lugged from one classroom to another.
Notorious failures have also been reported with equipment combining audio tapes and super-8 film. The speed of projection – fast, normal, slow-motion, still – was in one instance regulated by pulses recorded on the tape. This 'personal instruction projector' never made it: the ratio between the necessary investment and the learning yield was not convincingly enough in favour of closed-loop film.
The Librophon, a device developed in Germany and recently marketed in the Netherlands (under a different name), was another failure. The idea was to have small audio discs pressed into the plasticised page surface between or over areas of text. These could then be played using the device.
Then there were the video disc experiments of the 1970s, which cost a fortune. The discs in question were played by a stylus. A roughly similar disc is currently being marketed by RCA. Perhaps it will do better second time round. (First reports seem to suggest so.)
It might be interesting to compare the rapidity of introductions with the speed of the spread of writing and the concomitant evolution of reading and writing skills.

7.6 The role of the teacher

One of the great merits of our present system of education is undoubtedly that it guarantees a reasonable amount of schooling for everybody – at least in principle. When the system was designed, economic factors played a dominant role, and the classic frontal form of teaching was the result. The teacher functions as the source of information and as the director of the learning process. His view of life and mankind plays an important role in determining the content of the lessons.
Flexible education, individualisation and individual attention to students only become possible when a learning environment is created in which the students can to some extent find their own way and learn on their own or in groups for some of the time. Only then is there room for the teacher to devote his time not only to standing in front of the class but also to more intensive attention to individual students and groups, to working with other members of staff, and to preparing more varied teaching situations. To a large extent a learning environment of this kind is shaped by good teaching material, which must meet requirements other than those to which we have so far generally been accustomed in teaching methods and textbooks.
Other factors are important too, such as how schools are designed and equipped, the organising and teaching abilities of teachers, possibly parental participation, and good advice and practical support for schools and teachers.
But the availability of adequate teaching material is a major requirement. Here the audiovisual media have much to offer. In fact what we are dealing with is the achievement of the

aims of education with the aid of media. At all times the point of departure should be that certain changes in the shape of education are desirable – individualisation, greater self-reliance in learning, differentiation, and so on.
In education, innovation is never a smooth process. It works best, perhaps, through a step-by-step procedure in the form of a succession of small innovations. These might be innovations in a particular area or facet of teaching with relatively minor implications for other areas or facets – an innovation, perhaps, which does not go too far in undermining the teacher's system of standards and values, and which does not demand too great a change in his role and role relations in the classroom, and so on.

7.7 The product: information and knowledge

The diagram (page 52) may help to illustrate the foregoing. It maps the entire topography of the information/knowledge product.
The users must be the focal point of every decision. Who uses what, when do they use it, in what circumstances, and for what purpose? If the user can achieve his aim better, more easily, faster or more cheaply with a particular medium, he will be more inclined to use that medium. It therefore makes sense to involve the user in the development of media.

7.8 User affinity in the learning situation

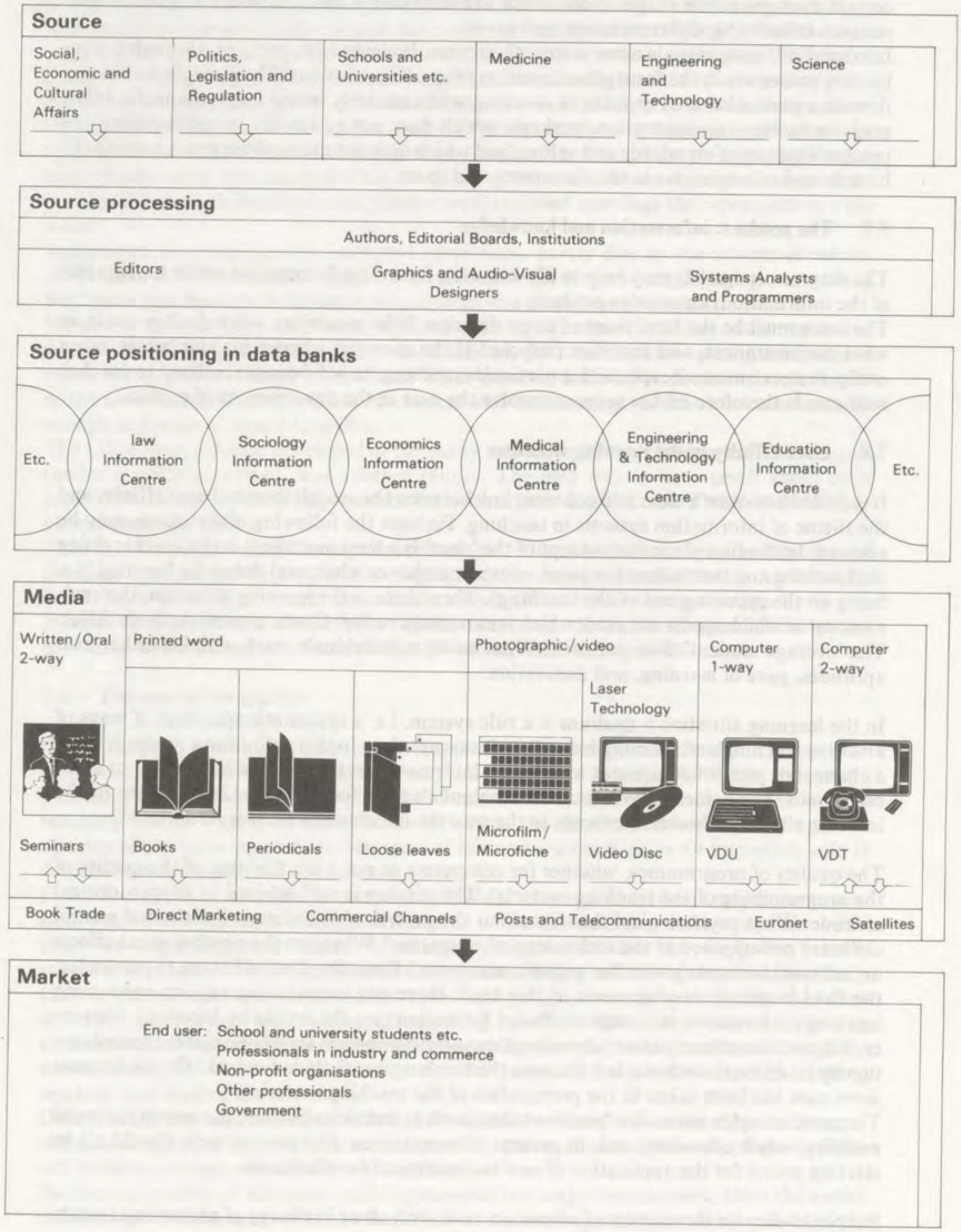
It is difficult to draw a clear and coherent link between the overall theme of user affinity and the theme of information systems in teaching. Perhaps the following observations may be allowed. In the first place the concept of the 'user' is a dual one: there is the teacher doing the teaching and the student (or pupil, course member or whatever) doing the learning (i.e. being on the receiving end of the teaching). Then there is the learning situation, the environment in which media are used, which is extremely varied. Curricula and methods differ. The 'average student' does not exist. What exists is individuals, each with his or her own aptitudes, pace of learning, and motivation.

In the learning situation a medium is a rule system, i.e. a systematic spectrum of ways of attuning teaching and learning behaviour to one another. In this definition a medium is not a channel or piece of equipment with which information is transmuted into visible or audible signals, but a means by which the content itself is formulated. User affinity in the learning situation therefore extends to the way the information itself is formulated.

The quality of programmes, whether for computers or not, [1] is a function of the quality of the programming of the teaching material. The teacher is well advised to adopt a critical attitude. What psychological theories about the growth of knowledge, insight and mental skills are presupposed in the technology of education? What are the psychological effects on individuals learning with the help of a computer? From the United States, in particular, the field leader in developments of this kind, there are encouraging reports concerning learning performance in Computer Based Education (see the article by Moonen). However, it is not immediately clear why education using computers should be better than education by traditional methods. Is it because the teaching is strictly individual? Or is it because more care has been taken in the preparation of the teaching material?
The more complex issues in education today, such as individualisation, the search for social mobility, adult education and, in present circumstances, finances as well, should all be starting points for the application of new technological developments.

Responsibility for the content of education rests with those in charge of educational estab-

Product: Information and Knowledge



lishments, or in this case the teaching staff. According to Article 208 of the Dutch constitution, the state must have no active part in determining the content of what is taught. This means that there will have to be a pluriform supply of software comparable to the supply of books, and it must always remain possible for a teacher to develop a computer program himself if he or she so desires. At the same time pluriformity in software can be achieved more readily if software is interchangeable and not tied down to one particular system or make.
One fairly obvious development is that there is likely to be a form of standardisation of teaching programmes which will on the one hand incorporate greater individualisation towards the student but in which the role of the teacher will have been altered and will be perceived subjectively as having been eroded. This might be described as an example of increased user non-affinity.

To judge by experience in commerce and industry there is also a danger that students will be required to adopt specific behaviour patterns, and that thought patterns will be imposed upon them which are at the very least questionable.

The technology of education always goes hand in hand with consumer technology, such as the technology of entertainment and of business information systems. There is often a superabundance of possibilities and problems because the equipment is not adapted to educational purposes. This has prompted the Swedish government to formulate standards to be met by microcomputers intended for educational use. These standards have been submitted to hardware manufacturers, and in this way it is hoped that a peculiarly Swedish school computer will be developed. One might then justifiably talk of a teaching aid.

For further reading see: [104]

Note

1. Perhaps in this connection it is relevant to draw attention to the experiments with LOGO currently being carried out with mini- and microcomputers in numerous places. With a minimum of extremely simple initial rules, students are given the opportunity to write programs, entirely according to their own insights, wishes and inclinations, for designing all sorts of highly complex drawings. Thus the student learns basic rules of construction and systematic repetition, and the related logic of coordinates and motion, literally as he or she plays. The practical user affinity is clear from (a) the enthusiasm with which primary school pupils want to use the computer, (b) the cooperation between them to exchange the programs they have written, (c) the ease with which this work fits in with existing teaching methods, and (d) the way in which, without severe intellectual exertion, students are able to acquire mathematical insights and skills.

8. The PLATO system

by B. Camstra

8.1 Introduction

PLATO is an interactive computer system for computer-assisted learning. Work on it has been going on since 1959, and in the process the system has gone through a pluriform evolution. The distinctive feature of the PLATO system is that it is not the consequence of a decision on the lines of: 'I've got this computer – now I think I'll use it for teaching'. The people responsible for developing PLATO (led by Donald Bitzer) set out with the idea: 'We want to configure the best possible system for teaching purposes. What requirements must we make of it, and how can they be realised?'

Computer systems for computer-assisted learning are used by an essentially different kind of user than most other systems. Until very recently, at least, almost all computer users were to some extent computer experts to whom working with a computer was only slightly less of an end than a means to an end. The users of a system for computer-assisted learning are pupils and students (for the sake of convenience I shall refer only to 'students') ranging in age from about 6 to, say, 60. They rarely have an understanding of computers, they are rarely interested in computers, and they equally rarely have any affinity with computers. When the work of developing PLATO began it was with this user group in mind. That is why the concept of 'user-friendliness' (or, as we are calling it here, 'user affinity') has been around for much longer in PLATO circles than in other areas of computing.

8.2 Outline of the PLATO system

Briefly, a PLATO system consists of a central large computer (a CDCCYBER) to which a network of PLATO terminals is linked. There are at present about twenty PLATO systems operating in the world, most of which are also linked to each other. In other words the world is covered by a PLATO network, all the terminals of which can communicate with each other.
The computer contains programs (called 'lessons') written in the special TUTOR language. Students go through these lessons on the terminals. The lessons are so organised as to create learning interaction. The general model is that the lessons present a piece of information together with a task, question or instruction to do something with the information. This may simply be to answer a question, it may be an instruction to calculate something or find something out, or it may be an instruction to take a particular decision. The cognitive processes which are jointly induced ('elicited') by the presentation of information and task are supposed to give rise to learning processes which will bring about a more or less permanent change in the student's store of knowledge and skills.
The student, as already observed, works with the PLATO terminal, the 'interface' between student and lesson. The terminal, therefore, has been given a number of input and output features designed with the student in mind.

On the output side there is the feature of high resolution – 512 x 512 addressable dots. This makes it possible to present a fairly high quality of graphic information. It is also possible, and perfectly practical, to introduce movement, which means that animated displays are possible. Efforts have been made to make both hardware and software of the presentation system as flexible as a school blackboard. One inbuilt feature of the system is that the teacher/programmer (called the 'author') can design and use his own character sets, so that all the Greek characters are available, for example, or, if desired, Arabic, Russian or whatever. The symbolic languages of particular subjects (electronics, chemistry or mathematics) can also be called on without effort, as can subscripts and superscripts, just as they would be on a blackboard. There is thus no need to confront twelve-year-olds, for example, with powers as 5**2 instead of simply as 5^2. Naturally it is also possible to make use of the usual visual attributes for drawing attention, such as reversed video, blinking, boldface characters and so on. It is also possible to hook up to the terminal a wide range of peripheral output media under computer control, such as a random access audio unit, various microfiche projectors, a video disc player, and so on (all, incidentally, using separate screens).

On the input side there is the use of a touch-sensitive screen. The user can point to a particular spot on the screen, the coordinates of which are then accepted by the system as interpretable input (i.e. input provided with meaning by the programmer). Another aspect is the user-oriented function keys, which have meaningful names such as NEXT, BACK, HELP, DATA, ANSWER etc. These are all, incidentally, redefinable.

8.3 Users

The users of this teaching system fall into three main categories, each of which can be further subdivided. The chief classes are students, teachers and courseware developers.

8.3.1 Students

The system's target group, and by far the largest group of users, consists of students, i.e. pupils at school, students at universities and colleges, and people following particular courses. Whatever one calls them, they all have the same role – that of a learner. Students can be subdivided into three subgroups, namely those with computer experience, those with keyboard experience, and those with no keyboard experience.

Students with computer experience
Generally speaking these are students following courses in which they have to deal with computers, e.g. mathematics, physics, computer science, etc. Of all groups of students, these most resemble 'experienced users'.

Students with keyboard experience
These individuals are commonly older than the average college or university student and are following courses in the context of their employment, or they are older-than-average students in non-computer-oriented subjects. The keyboard experience referred to here, incidentally, is not that expected of a typist (i.e. ten fingers blind), since that is never demanded of students, but familiarity with the QWERTY layout sufficient to enable the user to find individual characters without too much trouble.

Students with no keyboard experience
These are younger students and adults who have never used a typewriter. For this group the touch screen is a useful attribute and is highly appreciated.

8.3.2 Teachers

These are teachers and course tutors, generally not computer-oriented, who give guidance and assistance to students going through the lessons. They put packages of lessons together for students, assign sign-ons to students, keep student records and communicate with students through the medium of the system. They either already have keyboard experience or rapidly acquire it. The touch-sensitive screen plays no part here.

8.3.3 Courseware developers

These are sometimes teachers, sometimes programmers. In either case, those courseware developers who implement programs in the system themselves will have to carry out tasks which may be described as programming. I shall therefore refer to them as programmers. They use the system in the capacity of experts.

There are also a number of users concerned with the system on the 'meta'-level: people who use the system almost exclusively as an alternative to telex, people who only 'manage' other people's activities through the system. They most resemble the users of the group described in 3.2 above, i.e. the teachers. Apart from this brief mention I shall disregard them here.

8.4 User affinity

Having given a brief outline of the PLATO system and its users, let us now examine the system for various aspects of user affinity.

8.4.1 Memory overloading

Generally speaking, packages of lessons are prepared for students from which they can make a choice. The preparation is done by teachers, who have a number of utilities to assist them. These are all menu-driven. There is also a HELP key to which authors may assign a help function (this must be programmed anew as part of each new program). Then there are a number of function keys with permanent labels (DATA, LAB, BACK etc.) to which the author can assign a function to be defined by him. Here there is a hidden danger of overloading, since there is a total of 21 potentially available function keys (partly due to the use of SHIFTed versions). In practice an author will problably restrict himself to between four and six, the rest having no function but nevertheless being capable of inducing an unnecessary burden on the user's memory.
Lessons can be designed to offer the student a scale of choices, and here again there is a chance of overloading. However, this is entirely dependent on the author and cannot be regarded as a feature of the system.

8.4.2 Language

Students use the system almost exclusively within lessons, and what they have to say to the program there is 'prepared' entirely by the author. In most cases, then, it will be the student's own natural language. In lessons of a 'learner-controlled' nature, the author himself will have made a control language available, and he will also have determined how close it will be to the user's language. The main factor here is the designer's ability to develop something of this kind: the system itself has very little to do with it. The same applies to the extent to which the system responds sensibly to errors. This again depends entirely on the author in question. In practice this is not a frequent source of problems, though the TUTOR language used by PLATO does have special interpretation procedures to deal with problems when they do arise.
The language used to address the student is again almost wholly the creation of the courseware developer, and will therefore be designed with the student in mind. However, there is one problem here and that is that some program systems which manage the learning process through a package of lessons and which can be used by teachers for that purpose (these are known as CMI, or Computer Managed Instruction, packages) are available only in American English (and attuned, more importantly, to American culture). This does not produce a secret computer language but it does make for American educational technology jargon, and for many Dutch students and teachers this is just as incomprehensible. As a result, these CMI packages are often left alone by non-American teachers. And indeed there is no compelling reason why they should be used.

8.4.3 *Interpretation*

The touch-sensitive screen is a powerful aid in shortening the path from intention to result, since the student can operate on 'objects' very directly (he can point to them, move them, 'push' them up or down the screen, etc.) instead of having to look for equivalents on the keyboard. It might be supposed that, for younger students in particular, this feature would be well suited to the stage of intellectual development (cf. Piaget; but cf. also the Russian psychology of learning (Vygotski)). The 'hard' function keys too (as long as they have not been redefined by the author) can help shorten the path between intention and realisation: NEXT always goes on, BACK always goes back, HELP always offers help, and so on. But here there are two hidden hazards: in the first place some of these keys are not at all self-explanatory (LAB? DATA?), and in the second place the functions of keys are quite frequently redefined by authors, so that they sometimes lose something of whatever self-explanatory nature they originally had.
I have already observed that the system generally addresses students in ordinary language, in this case in Dutch. This means, once again, that the degree of interpretation necessary for its comprehension depends entirely on the author.

8.4.4 *System accessibility*

A student using PLATO must remember and correctly enter three things before he can get at the lesson or lesson menu prepared for him. These are his PLATO name, the name of the group to which he belongs, and his personal password (which he either chooses himself or has already chosen). A student's PLATO name will generally be his actual name, and the group will usually be referred to by some agreed title.
A typical entry by a student might then be: 'john' of group 'form 3a'. Sometimes there will be no need for a password. The inputs are insensitive to capitals/lower case but sensitive to spaces and punctuation. No error analysis takes place. There is one hazard: although normally all inputs (except single key inputs) have to be closed by pressing NEXT, the procedure after the group name is complicated in that SHIFT-STOP has to be pressed. This appears very strange at first but becomes automatic after a few times.
In most cases PLATO terminals are continuously linked to the computer using leased lines, and the procedure described above is all that is necessary. Where a dialled connection is used, the procedure of dialling naturally has to be gone through first, and that can be somewhat tedious and liable to errors and faults.
With the more modern stand-alone micro-PLATO stations a disk has to be loaded into the disk drive after which the user hits NEXT and is immediately at the start of the lesson intended for him (unless the author has deemed it useful to include a sign-on procedure as described above; the whole procedure is completely programmable).
In short: the system's accessibility can certainly be described as user-friendly.
The degree to which variables have useful default values depends entirely on the programmer of the lesson. In practice, lessons do not make a great deal of use of this, though NEXT is generally assigned a fairly obvious function, e.g. 'go to the first' or 'go to the next'. In utilities, which are used by software developers and teachers, extensive use is made of default values. It is here, in particular, that evolutionary development is evident: the more recent the utility, the more useful default values are used. In earlier utilities every option has to be selected explicitly.

8.4.5 *Search systems*

As far as the student is concerned the search systems are embedded in the lessons, and they are thus in the form chosen by the author. All sorts of search systems are used, but menus are the most popular. Keyword-oriented systems are more difficult to implement, and are less common for that reason. The search field within a lesson is generally not especially wide, so that menus do not usually go so deep as to prevent the student from having a mental picture of where he is. Depth is usually limited to three or four levels.

8.4.6 *Credibility*

The credibility of what the program tells the student is again largely a function of the author. However, there is one aspect which we can examine for a moment, and that is the faithfulness to reality of the information presented, and in particular the quality of the graphic information. For example: a stylised but nevertheless realistic and detailed representation of the human circulatory system may be considered good, whereas an attempt to achieve something comparable with punctuation marks, o's and x's will be regarded as bad. As a general rule it may be stated that a high screen resolution adds to this aspect of user affinity.

PLATO offers extremely good graphics from both the hardware and the software angle. The screen is built up from 512 x 512 dots, each of which can be switched on or off in any desired order. There are quite a few utilities (e.g. a graphics editor) to help the developer create realistic images. Superscripts and subscripts are easily obtained in both input and output. The system also offers enough computing power to be able to create reasonable animations, though in the case of on-line PLATO a limit is set on this by the 1200 baud input. Stand-alone micro-PLATO is faster at producing animations which do not require too much floating point arithmetic, and can create more complex animations. There are also some rather special input media available to the designer, such as the bit pad and the digitizer, enabling realistic images to be entered more simply, but it is still, of course, a digital approximation of an analogue reality. Mixing PLATO images with analogue TV or video disc images is not possible, nor will it be achieved in the near future due to wide differences in resolution and standards.

8.4.7 *Sense of security*

PLATO is a secure system, particularly for the naive user. There is simply nothing he can break, and he cannot wipe out lessons or get the system 'down'. The worst thing he can do (sometimes) is to lose some of the information stored on his own progress. To do any of the above, highly specific and difficult procedures would have to be followed, and that does not happen by accident. As a result, after some initial uncertainty one very soon sees users happily working with the PLATO terminal as if they had never done anything else in their lives. The touch-sensitive screen also makes a major contribution here. A student's sense of security or insecurity, of course, also depends to a large extent on the degree to which his behaviour in a lesson is adequately dealt with by the developer. For example, an inconsistent program response produces insecurity.

8.4.8 *Help*

As long as the software developer has specified something for it, the HELP key will provide help. The developer has simple utilities to call on in which many options are already set out (e.g. to send the student back the way he came). Once again, the quality of the help is a function of the quality of the author.

8.5 Conclusion

In the foregoing we have examined some aspects of the user affinity of the PLATO system for computer-assisted learning. The general picture that emerges is one of a high degree of user affinity. However, the actual user affinity of most aspects of the system revealed itself equally clearly as being highly dependent on the degree to which the author of the program had in fact made use of the available options. To put it another way: the system clearly offers more than enough facilities to be user-friendly, but no guarantee that this potential will actually be realised. To sum up, the PLATO system is potentially extremely user-friendly but the realisation of this potential depends to a large extent on the authors of the teaching programs.

For further reading see: [105-113]

8.6 A short note on computer-based learning

by Dr J. Moonen

Teaching aids and methods can only be allowed to exist in an education system if their use furthers the effective and efficient achievement of the purposes of education. In the development and execution of education the objectives occupy a central role. They may be regarded as definitions of the desired results of teaching and learning. These may be cognitive in nature, i.e. they may have to do with knowledge, insight, application and problem-solving, and the last three of these may be summarised as skills. Alongside these immediate objectives, education also has longer-term aims: learning to think logically and creatively and to work independently, and the acquisition of a positive attitude to a subject of study.

One can ask to what extent the use of computers in education – specifically, in computer-based learning – favours the achievement of these aims. This is to ask what is the functionality of computer-based learning. This functionality must be seen in the framework of the various educational functions involved in the teaching/learning process, e.g. functions relating to the proper preparation for a lesson; functions relating to the actual acquisition of knowledge and skills; and functions relating to feedback to the student. In more general terms we refer to information, activation and evaluation. This is turn raises the question of how computer-based learning can be conducive to the achievement of those aims or, in other words, what demands have to be made concerning the way those aims can be achieved in interaction with students. This is the problem of user affinity.

It will be appreciated that it is easy to use a computer to provide a student with information and to evaluate his progress. However, computers only become really interesting in this context if they can be used to combine the functions of informing, activating and evaluating. For example, one might conceive of a program which starts by giving information, then evaluates the student's level of knowledge or skill, and finally – if necessary, and always according to requirements – develops an activating activity appropriate to his potential. A computer, after all, is a machine which is capable not only of fulfilling all these functions at the same time but also of doing so in direct dialogue with the user. It can be used as a programmable machine, but it can also be used for computer-assisted teaching – as a machine that serves as an electronic blackboard to illustrate concepts and results and as a machine which, through automatic data collection and processing, will select, and possibly even generate, the program elements appropriate to the further course of the student's learning process. This is where the computer can be genuinely functional, i.e. can carry out

tasks which would otherwise be extremely difficult and laborious. This broad use of computers does, of course, make special demands of the computer system and the associated software: one might say that as far as possible the system has to have the characteristics of an intelligent partner. This calls for quite a wide range of abilities and facilities, including those relating to system input and output. In the case of output this means the accurate representation of images, text and sound. This can be achieved by means of a screen with high resolution and colour and one that is suitable for the presentation of moving images and film. At the same time, the reproduction of sound in the form of beeps, musical tones and speech synthesis must be built in. It must also be possible to make a hard copy of any screen. The ideal mode of input, of course, would be the natural language, but this is not yet attainable. For fast and direct interaction between student and program it is therefore desirable that as little as possible should have to go through the keyboard. There are various methods – such as touch-sensitive screens and 'mice' – that can help bring this about.
One of the chief characteristics of computer-based learning is the dynamic process that arises in the interaction between student and program. I have already said that to achieve this the system must have good and rapid input and output facilities. It must also have enough computing capacity to react to the student's input within one or two seconds at most. The dynamic quality of the process is ultimately determined by the possibility, on the basis of the progress made by the student and his teaching requirements and decisions, of working through the whole of the available material along paths which the student chooses for himself. This is how computer-based learning comes under the control of the student, and in the context of furthering the long-term objectives referred to earlier this is extremely important. For it to be possible, the program has to be extremely flexible in use, both in its presentation of the material and in its interpretation and processing of and reaction to the student's answers and commands.

I said earlier that teaching aids and methods must further the effective and efficient achievement of the purposes of education. Is this true of computer-based learning? Kulik *et al.* [115] examined this in a summarising study of 59 investigations previously reported elsewhere. The following conclusions may be drawn from their survey.

- Average student performance is somewhat better with computer-based learning than in other forms of education; the difference is statistically significant but not very substantial.
- With computer-based learning the relation between a student's aptitute and his progress is less apparent than in other forms of education, but this difference is again not very substantial.
- With computer-based learning, students' attitudes to the form of teaching and the subject area concerned are slightly, but not significantly, more positive than with other forms of education.
- With computer-based learning the percentage of students dropping out is slightly, but not significantly, smaller than with other forms of education.
- With computer-based learning the time spent on the course is reduced both significantly and substantially; reports show an average gain of 30%.

These results may be felt to be disappointing as regards effectiveness. However, they are not particularly surprising, since in this sort of survey the comparison is based far too much on overall results. Dublin and Taveggio [114] had shown earlier that the overall comparison of teaching methods reveals virtually no differential effects.
This means that justification of computer-based learning on grounds of improved learning performance can only be expected from research concentrating on and related to the specific functionality of this application in the teaching/learning process and to longer-term

educational objectives. The study referred to does, however, provide an argument in favour of the thesis that computer-based teaching methods improve the efficiency of education. It is legitimate to suppose that its optimisation is closely bound up with the user affinity of the system used.

III. Synthesis of practical experience; aspects of user affinity

1. Introduction

This chapter summarises the various aspects of user affinity. It is not intended to provide a theoretical framework, for the simple reason that our theoretical understanding of the problems encountered is still inadequate. Instead we will deal in turn with those aspects of user affinity which have proved to be important in practical applications.
This appraisal is based on the case histories contained in Chapter II. Since this study focuses on man as the user of the information system the user affinity aspects are discussed from the viewpoint of human factors.
There is one obvious drawback to this approach. It is more difficult to express an aspect of user affinity in terms of design criteria than would have been the case if the question had been approached from the technical angle. The advantage of the 'human approach' is that it is homogeneous, and enables comparisons to be made with what we know of human behaviour.

Since this report is intended to be an overview rather than a manual, the aspects are described in broad terms. The literature references will direct the reader to the more detailed information and discussions. An attempt has been made to indicate the relative importance of the aspects and to identify problems which have not yet been resolved. Areas requiring more in-depth study will be indicated where appropriate.
Breaking the concept of user affinity down into its constituent aspects does not tell us what user affinity actually is. An instrument has been developed for measuring computer user satisfaction [116], but the connection between satisfaction, user and organisation performance is still unclear. The problem is that user affinity is part of an interlocking complex of factors and circumstances. It can change in the course of time, and ultimately it depends on the individual user.
A few of the aspects of user affinity given in this chapter are interdependent, so optimising one aspect can affect another. A second difficulty is that some aspects are more important than others, and in many cases they are only partly amenable to objective measurement.
As pointed out in Chapter I, user affinity can mean very different things to different users. In general it will depend on the user's education, experience, intellectual ability, requirements, expectations, goals and tasks.
In this study we distinguish between three different levels when interpreting the concept of user affinity. On the first level it concerns the effectiveness and personal comfort of the exchange of information between the information system and its direct user. On the second level it is seen as a factor determining the operation of the man-machine system as an entity in its immediate environment or within the confines of an organisation. On the third level user affinity covers the question of reciprocity. How will the use of information systems affect human behaviour and thinking in the years ahead?

Aspects associated with the first and second of these levels are classified as follows.

Perceptive and psychomotor aspects	The form of interaction, means of input and output
Cognitive aspects	The content of the information exchange
Emotional aspects	Attitude towards the system

Environmental aspects	Functional aspects of a specific task, psychological and physiological stressors
Organisational aspects	Aspects experienced by the user which mainly concern the integration of the man-machine system in its environment

Needless to say, the case histories did not produce any third-level aspects, so they will not be discussed in this synthesis. We will be returning to this point in Section IV.10.

2. Perceptive and psychomotor aspects

The exchange of information between a human being and an information system proceeds through an interface of input and output devices.
The distinctive feature of a user-friendly method of input is that the input devices are ideally suited to the user's task and to his limitations in using the system. Similarly, a user-friendly method of output dovetails as closely as possible with the task to be carried out by the user. The user enters information using a variety of devices, such as keyboard, joystick, mouse, trackerball, light pen, touch screen and, most recently, voice input.
Information is generally presented to the user by means of screens, digital and analogue meters, and graphic displays. The main use of auditory output devices is for feedback (on input) and for sounding warnings.
There are various ergonomic and psychological aspects which have to be taken into consideration when designing user-friendly input and output devices.

Anthropometrics
Anthropometric studies deal with the design of work stations and machines and their adaptation to the physical capacities and limitations of human beings.
The key factors in this process are the measurements of the static and dynamic parameters of the human body. Static parameters include body dimensions, arm and leg reach, and visual field. Dynamic data are obtained from studies of movement and the exercise of force.
Anthropometric data are seldom sufficient for practical design purposes. Discussion with future users and case studies of problems noted in work situations can provide the designer with a great deal of additional information. Input and output devices and other equipment at the work station can be user friendly if the user can adjust them to suit his or her particular requirements.
However, it is by no means certain that the user will make the correct ergonomic choice, for there is often a considerable difference between subjective and objective ergonomics. For instance, too much freedom of choice in adjusting tables and chairs often leads to unsatisfactory configurations. Ergonomic publications contain specific recommendations for designing input and output devices and other equipment [15, 117, 118, 119].

Sensory and perceptive aspects
The realm of observable stimuli is determined by the keenness of our senses. The limits of that realm, however, are fairly vague, with the chance of detection rising gradually from zero to 100%. Moreover, attention focus and perceptive strategies determine what information is absorbed for further processing, how it is processed, and what information is rejected or ignored.
An understanding of the characteristics and limitations of sensory and perceptive systems is essential when it comes to designing input and output devices. This report is not the place to

embark on a detailed discussion of the various subsidiary aspects. The interested reader is referred to publications [118] and [119]. Factors affecting the presentation of information on VDUs are screen size, layout, use of colour, size and shape of letter, and length of presentation. The question of legibility has been well researched, and there are now guidelines on letter size, shape, and length of presentation [120]. There is far less information on the effect of screen size, colour and layout, and we know next to nothing about the interaction between those factors as it affects the capacity to process the amount of information presented [119, 121]. Some of the aspects which the case histories showed to be important are discussed below.

Layout

One would imagine that the high level of sophistication attained by the printing industry would have provided numerous pointers on the way to present information on VDUs.[1] In practice, though, screen layouts often break elementary graphical rules, and one wonders why more use is not made of the available expertise and why graphic designers are not canvassed more often for their views on the presentation of screen information.

Information presentation can be broken down into the following aspects.

- Information structure (body text, tables, diagrams, etc.).
- Information density (amount of information on a full screen).
- Coding parameters within the information structure (colour and brightness, blinking, shape, reversed video, etc.).
- Information hierarchy (hierarchy of information structures).

The general rule is that the method of presentation must match the perceptive stategies used by human beings [122]. Among other things this means that elements which are spatially or temporally related should be presented together. The most important information should also be displayed as close to the centre of the visual field as possible, for this is the area where the prospect of accurate and rapid perception is the greatest [123].

Colour

The use of colour on display screens is effective when specific elements have to be retrieved and colour is the dimension in which discrimination takes place. For other tasks, such as reading a text, colour tends to be intrusive rather than useful, since a display which is too 'busy' is distracting. Generally speaking it is better to keep the use of colour to a bare minimum, even for retrieval tasks, since its effect (coding efficiency) is lost if the user is swamped by too many colours [15]. It should also be remembered that some 8% of all males are colour-blind.

Compatibility

In psychological terms, compatibility is a measure of the match between stimulus and response. For instance, when a user enters a Greek alpha (by pressing a function key and the 'A' key) the screen, as well as the print-out, should show an alpha and not an ordinary 'A'.

In terms of motion, compatibility means that when the joystick is moved to the right the window should track to the right.

In conceptual terms we know that people associate the colour red with danger, unsafe, etc., and that green signifies 'safe', 'proceed', etc.

1 It should be added that even graphic designers break their own rules as a result of conflicts between artistic considerations and the rules of perception.

Finally, as regards spatial compatibility, it is important that the configuration of switches on a control panel should match the configuration of the gauges. Wherever possible the panel layout should be made compatible with the internal representation held by the system operator. That representation may be based on a schematic diagram or on the actual layout of the plant.
Closely related to compatibility is the fact that experience and acquired knowledge lead human beings to have certain expectations of a machine. A typist, for instance, expects to find a QWERTY keyboard, and in fact her typing skill depends on it. Satisfying compatibility requirements and expectations leads to faster training and fewer errors, particularly in circumstances where stressors are present.
The greatest possible standardisation of input and output devices in accordance with the above principles is a major contribution to the user affinity of information systems.

Feedback
Human beings expect some kind of response to tell them that their actions have had some result. Without that confirmation it is extremely difficult to plan or undertake subsequent actions. In man-machine systems this means that the system must respond to operation and input.
This feedback can be tactile, auditory, or visual.
Overcoming resistance when a key is depressed provides the user with the necessary tactile feedback. If a printer starts to hum when we switch it on we know that it is working. One interesting aspect of auditory feedback is that an audible rhythm accompanying the act of typing can have a positive effect on performance. In the case of visual feedback, every entry or operation must generate a visible representation or change of state, however temporary.
Another aspect is the speed of feedback. For instance, it is known that entry echo should occur within 0.1 seconds [21, 123]. The general rule for feedback is: the faster the better. Users often encounter delays after they have given an instruction to the computer system. Leaving aside the length of that delay, it is important that the variance for identical situations should be kept as small as possible. Inconsistency causes irritation. The maximum permissible delay after giving a simple instruction or for receiving an error signal from the system is 2 seconds. It has been found that 15 seconds is an acceptable delay for a highly complex instruction [21]. Progress information should be provided during long delays.

3. Cognitive aspects

Cognitive aspects are concerned with the content of the information exchange, with comprehension. They clearly play a role in every man-machine interaction, but they are particularly important in the case of an information system, which is above all an aid and a tool reinforcing and expanding human intellectual functions. In effect, information systems are extensions of the human brain.
As with any tool, the user has to familiarise himself with the information system. He has to learn how to communicate with it, what its capacities and limitations are, and how it can help him to carry out his task.
Cognitive aspects play an important role in the areas of user support, communication between man and the system, and dovetailing user and system in the performance of a task. A number of those aspects are discussed below.

3.1 Learning, remembering and forgetting [125, 126, 127]

Accessibility

The user's first problem is how to gain access to the system, in other words how to get it to communicate with him. Irregular users should not be forced to go through a learning process – access should be immediate. Generally speaking it is only if the first attempt fails that the user will consult an instruction book or manual. In the interests of irregular users, then, the access procedure should consist of as few steps as possible. The provision of help options during this procedure can eliminate many problems, which brings us to the role of user support.

Familiarisation

Familiarisation with an information system means that the user must get to know the system, so that he can meet the input requirements and understand the system output. The use of the system must also be integrated in the user's performance of his task. The successful completion of the learning phase is extremely important, both in terms of costs and benefits for the organisation, and also for boosting the user's motivation and his willingness to work with the system. Some form of theoretical instruction is still the most common form of user support. It may take the form of a training course, but more often it will be a manual, directions for use, etc. In practice, though, the written material often proves less than satisfactory.

There are various reasons for this. New material has to fit into the form and content of the user's cognitive system, and this in turn demands an adequate number of anchor points. In other words, there have to be enough 'pegs' on which the new information can be hung. There is often a considerable discrepancy between the assumptions of prior knowledge made by the compilers of manuals and the actual prior knowledge possessed by naive users.

Manuals are usually system-oriented, and they tend to give a thematic description of the features of the system in a way which users find extremely hard to follow. In so far as a manual is actually aimed at the user it would be far more valuable if it were user-oriented, in other words if it were written in a way which matched the user's goals.

One defect of many manuals is that they frequently fail to distinguish between really important points and side issues. If one is learning how to handle a word processing program it is not necessary to know all the system commands. Some of them are essential, and are used often, so they should be emphasised. The object should be to enable the user to work with the system with the least possible delay, not to bury him or her in an avalanche of words describing all the available options of the system.

The greatest drawback to theoretical instruction, however, is inherent in the medium itself. Theory offers no informational feedback. It is a one-way process, and yet we know that interaction speeds the learning process.

Secondly, the user has no control over that process; he is unable to direct it into the channels he actually wants or needs to explore.

All these factors argue for an expansion of the help options in the system software. 'On-line' learning on the basis of interaction, with the user receiving information on errors and instructions on the correct procedure, and being able to direct the learning process himself, can produce users who are more motivated and who become active users more rapidly.

Transfer of training and interference

A problem arises when a user is confronted with a large number of different systems or with the need to transfer to a new system. The willingness to be constantly mastering new instructions is small, and on top of that there is a growing risk of interference between the various instructions and procedures. This problem of interference becomes all the more acute when there are only minor differences in the instructions. Standardisation is recommended, wherever possible [125].

Forgetting

Any discussion of learning and remembering would be incomplete if it did not also consider the question of forgetting. It is often implicitly assumed that once people have learned certain instructions, rules, procedures and emergency procedures they remember them, and know how to use them.

Unfortunately, though, this is simply not true. Interference between different material can result in the non-application or incorrect application of the directions for use. Time is also an important element in the process of forgetting. For instance, problems arise when a system is only used sporadically. Whether or not the knowledge has actually been forgotten is only of theoretical relevance. The point is that after a while the rules are applied inadequately, if at all. This problem becomes more acute when the user is confronted with infrequent events. He can no longer recall the proper procedure to be followed, and if he is working under stress he is unlikely to make the correct response. Compatibility is an absolute precondition for the correct response in emergencies.

User support

Accessibility, familiarisation with the system, transfer of training, interference and forgetting are all aspects which can be enhanced or corrected by user support employing help options, and by standardisation.

The operation of an information system generally makes a constant and varied demand on the cognitive ability of the user, and it is inevitable that that ability will occasionally fail him for an instant. He will suddenly forget what he has to do in order to achieve a particular result, or perhaps he has not yet learned the appropriate procedure. While he is working he must therefore be able to turn to someone, or something, for 'on-line' assistance in solving his momentary, local problem.

The availability of that assistance, in a form tailored to the specific problem that has arisen, is a user-friendly feature. The user should not have to embark on a long search through the help utility before he finds the information he needs to solve his problem. He must also be able to return, quickly and simply, to the point where he got stuck, and by 'quickly' we mean that he should only have to strike a single key.

Broadly speaking, the need for assistance is greater:

- the less routine the task;
- the wider the range of sub-systems used;
- the less experienced the user;
- the more incidental the use;
- the greater the demand on the user's memory;
- the less the opportunity to train the user properly for the task;
- the more frequently the task or system is changed.

3.2 The dialogue, man-computer communication

There is a considerable difference between the way in which people communicate with each other and the way in which a human being can communicate with information systems. This is a trivial observation, admittedly, but human communication is the only available yardstick for designing dialogues, and a closer examination of some of those differences may help us understand the direction in which man-computer communication should evolve.

People taking part in a conversation have a number of characteristics in common [128]. They include common modalities of representation, linguistic capacities and thought processes; knowledge of each other's backgrounds, of the subject being discussed, and of social behaviour; adaptability/flexibility, changing the topic of conversation, reverting to a previous topic, correcting a previous statement, and so on.
By these standards information systems make poor conversation partners, and that does nothing to help the process of communication. In so far as it is technologically possible, though, it is well worth organising the communication process so that it matches the above characteristics as closely as possible. Some of those aspects are discussed in the following paragraphs.

Language
'Language', in this context, means two things: the language in which the user 'addresses' the system, and the language in which the system presents the user with the information he has asked for. In neither case does it necessarily resemble a natural language. It can equally well consist of a collection of function keys with rules governing the way they can be combined.
If the means of communication between the user and the system is an artificial language the user will have to learn it before he can use the system. This can reduce motivation, and lead to irregular use, long learning periods, and the creation of a kind of elitism.
Against this, an artificial language can take the ambiguity out of communication (making it less susceptible to errors and misunderstandings) and reduce redundancy (enabling the experienced user to work more rapidly with the system).
The most suitable language depends largely on the kind of task to be performed. Algebraic notation is more suitable for solving mathematical problems than the language used for interpreting a poem. The criterion is not that the communication languages should always be as close as possible to a natural language, but that the form and content of the dialogue should answer the purpose of the interaction.
In human communication the level of language depends on the degree of linguistic knowledge of the participants. Level means both the general linguistic level and the specific, communal linguistic level related to the topic under discussion. Ideally, then, the man-computer dialogue should be capable of functioning at different levels.

Knowledge
Participants in a conversation share a certain amount of knowledge about the topic under discussion, and the nature of the communication depends to a large extent on that knowledge. Interactional problems can arise when the nature of the communication does not match the level of knowledge on either side.
In the course of a dialogue, information systems sometimes display information which is totally incomprehensible to the user, so he should always be able to ask for clarification. On the other hand, the user must know the limitations of the information system. Errors are sometimes corrected automatically by a human partner, but information systems generally lack this ability. User affinity benefits if the information system is given a good idea of inputs which are and are not permissible. If it receives an unexpected entry it can then ask whether that is really what the user intended.

Adaptability
One essential feature of human communication is adaptability, which enables us to comprehend messages which are badly or half formulated, to change the subject suddenly, to ask for an explanation, and to modify earlier statements or agreements.
Many information systems appear to be totally incapable of adapting, performing like

humourless pedants who dot every 'i' and cross every 't'. This is extremely irritating, particularly when the rules governing the interaction are strict. In some systems, for example, certain commands have to be separated from each other by pressing the space bar, others by a separation sign, and yet others by commas or colons.
Problems also occur when input fields have a certain maximum size, or when command strings have to be re-entered in their entirety because of a single syntactical error. Another point which must be mentioned is the reversibility or otherwise of commands once they have been entered. This is sometimes referred to as the extent to which the system is foolproof. The advantage to the user is that he knows he cannot precipitate a disaster by making a simple mistake. In practice this is because commands with far-reaching consequences require more than one action. Specific recommendations on man-machine dialogues will be found in [21, 43].

3.3 Some task variables, the user's internal representation

When the man-machine system is being designed the various sub-tasks have to be apportioned between the man and the machine. The determinants here are the capacities and limitations of the computer system and those of the user.
The degree of harmonisation between the actions to be carried out by the user and those which are left to the machine is crucial to the combined performance of the two. The ideal match requires a knowledge of the task to be performed and the way in which the user perceives the various elements of that task.

The task
Work (or labour) is carried out by human beings using aids and tools. Work consists of a number of tasks which are divided between the man and his tools. A task is defined as the smallest subset of a job which can be entrusted to an individual or to a tool. The sum of the tasks allocated to an individual is his or her job. Questions which have an important bearing on the distribution of task between humans and tools are: What can a human being do that a tool cannot, and vice versa; what can a man perform better or more cheaply than a tool, and vice versa; and what does a human being not want to do, or what should he or she not be expected to do?
The difficulty of a task depends on various factors. The first is the degree of determinism, i.e. the predictability of events and their sequence. The more predictable they are the easier the task.
The second factor is complexity. Task complexity is a concept which tells us something about the number of elements (sub-tasks) and the number of relationships between those elements.

Internal representation [129]
People construct various models of reality on the basis of their knowledge and experience. Such a model is known as an internal representation, and its complexity depends on the complexity of the reality with which one is confronted. It should be added, though, that there are limits to the complexity which human beings can master. This is illustrated by the work of operators in process industries.
The following are a number of critical points.
- If the actual process is extremely complex (and particularly if the various elements are highly interdependent) the internal representation will be a simplified model, with a number of elements and relationships lacking.
- If the actual process has a long response time the task takes on the nature of an open loop. The operator, however, can carry out closed-loop experiments in his mind.

- If those mental experiments are to be successful the internal representation has to bear a close resemblance to the actual process. If that is the case the operator will receive that information from the system which meets his expectations.
- If the process is so complex that too many elements and/or relationships are missing from the internal representation the result may be that the actual process bears no resemblance to the prediction based on that representation. In that case the internal representation has to be modified. Unexpected information is often processed less efficiently.

Our knowledge about internal representations is sketchy in the extreme, so this is a large research area still waiting to be explored. It is impossible to make any specific recommendations, but in general terms we can say that the designer should try to assist the operator as much as possible in forming a correct internal representation of complex systems. This could be done by ensuring that the system is no more complex than it need be, and secondly by providing instruction. The adequacy of internal representations can only be tested in situations where a process starts to go wrong.

4. **Emotional aspects** [124, 130]

The basis for a properly functioning man-machine system is laid during the design stage. An understanding of the perceptive, motor and cognitive aspects of human performance is essential for a good interaction, and the same applies to the user's emotional response to the system. We have already touched on a number of emotional aspects in the preceding sections, but that is not surprising when one remembers that emotional factors invariably play a role in human behaviour. The following paragraphs are devoted to several aspects which have not yet been mentioned, or which have not been discussed fully.

Acceptance

People's motivation and willingness to work with information systems vary widely. Attitudes towards these systems are made up of various beliefs about the object in question, but those beliefs are not necessarily founded on fact. It is more a case of characteristics which are observed subjectively and then projected onto the object. Many people are relatively unfamiliar with information systems, and human beings have a tendency to come to rapid and negative conclusions on the basis of only a handful of facts. This can be countered by involving future users in the design stage, so that they get to know about the capacities and limitations of the system. Another aspect of this 'user participation' is that people are far more inclined to observe rules and follow instructions when they themselves have had a hand in framing them. In addition, people will more readily accept an information system when they see that it works to their advantage. Users often have only a very rough idea of what they want of an information system, which is partly due to their lack of knowledge about its capacities and limitations. Involving users in the design process can accordingly contribute to a better formulation of the user's wishes.

Ignoring users' requirements and wishes results in unnecessary problems and extra costs, such as a resistance to change, inefficient use patterns, and an under-utilisation of the system [130]. One factor which has a major bearing on acceptance is the user's pattern of expectations. If he expects to benefit greatly from using an information system he will be far more inclined to be adaptable and will take greater pains than he would if the anticipated benefit is slight or uncertain. Another important, and related aspect is the credibility of the system, i.e. the extent to which the user can trust the system to give him accurate, complete information.

Credibility is a precondition for the acceptance of any information system. This applies to both inexperienced and experienced users. The former will immediately reject a system they regard as unreliable while the latter may continue to use it, but with reservations. What is user-friendly in this context? This question is not as trivial as it seems. Reliability, of course, is a user-friendly feature. But on a less trivial level it is a fact that a system which produces information whose accuracy is beyond doubt (by definition or otherwise) is more user-friendly than a system where the accuracy of the information constantly has to be checked or assessed (even if it *is* generally correct). The latter system also tends to make greater cognitive demands of the user.

Dependence

As with any tool, an information system has to be available for use, and technical reliability is an absolute precondition when the user depends heavily on the system for the performance of a job. In addition, the user must feel confident that the system will provide him with reliable information.

Anthropomorphisation

People occasionally tend to anthropomorphise information systems, This is particularly common with systems which accept natural language, or which present themselves in natural language.

Weizenbaum [128] describes people's experiences with the computer program ELIZA, which performed as a psychotherapist. Although the experimental subjects knew very well that there wasn't a person behind the screen they tended to let the system into their confidence, and wanted to be alone with it. Anthropomorphisation, however, creates certain expectations which the system cannot possibly satisfy, with the result that it is rejected as being incomplete. It is undesirable to suggest an element of user affinity which the computer does not in fact possess.

Control of the system

The user must have the feeling that he or she is in charge of the system, and not the other way round. This aspect is closely allied to several other cognitive and emotional factors, notably flexibility and dependence.

Privacy

There are three kinds of privacy in the field of information systems. In the first place there is the need to protect the private lives of ordinary citizens about whom data is stored in an information system. Since they are not the actual users of the system this aspect of privacy is not, strictly speaking, an aspect of user affinity as defined in this report. In view of its great social importance, however, it is discussed in Section IV.7.

The second aspect of privacy concerns the ability to observe the user of the information system. From the technical point of view there is nothing at all to prevent the recording of a user's entire interaction with an information system. It is not easy to give a general pronouncement on the extent to which this practice should be curtailed. Checking the work of a professional colleague is observation of a totally different order than recording the use of a documentary information system by consumers. Section IV.6 discusses the latter instance.

The third aspect of privacy concerns the protection and use of data entered into the information system by the user, who would like to know that they are secure, and who may even claim exclusive rights to their use. That kind of protection may place demands on the system which conflict with the interests of accessibility. It is possible to protect a user's data by introducing passwords which are changed from time to time and which do not appear on the screen when they are entered. The equipment could also be fitted with locks. A user-friendly system will strike the optimum balance between accessibility and privacy. In any event, it must be possible to determine that optimum per application, in other words per user. A system containing data from newspapers which could be gleaned by anyone requires a different form of protection from a military system with calculations on new missiles.

5. Environmental aspects

The effectiveness and efficiency of the exchange of information between man and technical information system are affected by environmental factors. It cannot be assumed that the physiological and psychological state of the user never varies, for human performance alters under the influence of changes in working conditions.
Those conditions are known as stressors, and they can be subdivided into physiological and psychological stressors.
Examples of physiological stressors are tiredness, lack of sleep, the time of day, temperature, noise and restricted movement. Psychological stressors include information overload, threat, monotonous work, pointless work, vigilance and distraction.
Stressors affect the activation of the organism. The connection between activation and performance is represented by the classic law of Yerkes-Dodson: an inverted U which shows that there is an optimum level of activation. Both under-activation and over-activation reduce performance. The optimum activation level is crucial to the performance of complex tasks.
There are three other important points which should be mentioned here. In the first place, people react very differently to stressors, and designers of machine systems must take this into account when designing a system which is to be used by a large number of people. Noise, for instance, affects some people more than others.
Secondly, a person's sensitivity to stressors varies. The noise of someone else's printer, for instance, is often more irritating than that of one's own.
Finally, the effects of the different stressors cannot simply be summed, as the following example will show. Both monotonous work and excessive noise can have a negative effect on performance. On the other hand, the effect of monotony can be alleviated by the deliberate introduction of noise. The user affinity of an information system must be studied under the most extreme conditions affecting the man-machine interaction.

6. Organisational aspects

Flexibility
Organisational structures and task allocation within organisations are not immutable quantities. They change in the course of time.
New tasks arise, while others are modified or combined. Organisations can centralise or decentralise, goals can change, and so on.
Consequently, information systems within organisations are also subject to change, and it is for this reason that the literature mentions flexibility as one of the main requirements of an information system. Flexibility also embraces the extent to which a system which has already been introduced in the organisation can be modified and expanded.
A good example is provided by the Academic Medical Centre in Amsterdam, which switched from a line organisation to a matrix organisation when it moved into its new premises from the Wilhelmina and Binnen Hospitals. Under the new system there is a very different structure of authority and tasks. Not only must the information system function

properly in this new matrix organisation, but it must also be capable of adapting to new insights and to refinements required by people working in that organisation. The organisations must also be able to determine the speed of introduction themselves and to control further integration within the information system. The flexibility or otherwise of the information system partly determines the freedom of action.

Integration
In addition to flexibility, which basically determines the extent to which an information system is 'future proof', there are a large number of other requirements which affect users' assessment of a system. In this synthesis we will merely mention the degree of integration of the various sub-systems within an organisation and various requirements in the realm of effectiveness, such as response time, the timely presentation of information, and the integrity and security of the system.

One aspect of integration is the compatibility of the various sources of information. It is by no means rare to find data which are used for several applications being entered and stored more than once, with all the resulting problems (including redundant data storage and data inconsistency). One even comes across cases where the output of one automated system has to be entered as the input for another system because codings differ, formats are not matched, and so on.

It goes without saying that such 'islands of computerisation' are extremely irritating for users, and actually hamper them in carrying out their duties, where cooperation should be the watchword. An information structure which more closely resembles a tower of Babel than an integrated system is disastrous for an organisation, damaging its ability to work either effectively or efficiently.

Another and more important aspect of integration is congruence between information systems and organisational structure, also referred to as organisational fit. One example of this kind of integrated system is described in the case history 'The integrated hospital information system' (Section II.4). The user affinity of such an information system is marked by a good fit between the functional structure of the computer system (including the networking facilities) and the structure of the organisation. Existing patterns of communication, between departments and digital information flows for example, have to be dovetailed in an integrated structure of that kind. To the best of our knowledge relatively little research has yet been carried out in this area.

Integrity
Effectiveness requirements are also major determinants of the users' perception of a system as user-friendly (or not). In the present context it is sufficient to mention the requirement for integrity, which can in turn be subdivided into the need for availability and the need to receive accurate and complete information. Availability is partly determined by down time, the provision of back-up systems, and the speed of repair and maintenance. An availability which is low or which fluctuates wildly is obviously experienced as negative in the extreme, particularly in environments where on-line and even real-time processing are both desirable and essential.

If the system does not work, or only works partially, whether or not that is planned, the user should be told so without any quibbling, and he should also be told when the system will be available again. Professional users, in particular, want to know where the fault has occurred in the system so that they can form their own idea of how long it will take to rectify. If a system or part of a system goes down the user must be able to switch as simply as possible to a fallback situation in which only part of the information system is available, or make a complete switch to a manual procedure.

The user must be told when the system has been restored to normal operation, and his

return to that system must be made as smooth as possible.
Moreover, care must be taken to ensure that the data from the fallback situation reappear in the information system, provided that is relevant and necessary. The reader is referred to Section IV.8 for a more detailed discussion of these aspects.

IV The future of user-friendlier information systems

1. Introduction

This chapter consists of nine articles looking at the future of user-friendlier information systems. Besides giving a general idea of opinions held in the areas concerned, some of these contributions provide answers to more specific questions, which are printed at the head of each article and which were formulated by the authors of the case histories in Chapter II, with reference to the problems identified in Chapter III.

2. Designing user-friendly information systems

by Prof. J.M. Dirken.

2.1 Why do we need the concept of user-friendliness?

One is bound to ask oneself to what extent user-friendliness, or the humanising of operation and use, or suiting the technical design of the system and its interface to man, belongs among the humane extras that are added, somewhat luxuriously, to the primary functionality of an information system. Or are we dealing instead with design aspects which have a directly determinant effect on the effectiveness and efficiency of the information-processing system as a whole and thus of the information system together with its user? Though it would be appropriate to add the rider that information systems are not equally important to everyone, we would appear to be dealing with technical aids which are fulfilling an increasingly important function as components of and supplements to human cognitive and social functioning. Mismatching at this level is probably more serious than with other types of technical aid, which serve 'only' as extensions of muscle and bone functions, such as hammers, tweezers or a vehicle, or of the senses, such as spectacles, television or radio. User-friendliness, however vague and fashionable it may be as a concept, is an essential property of an increasingly significant type of technical aid: it is the property of ergonomic quality, which by more skilful and more careful conception and design must be realised for all or the majority of users. It is a property hitherto largely neglected, or only involved in the design of information systems at a late stage.

2.2 Unmannered information systems

An information system can only fulfil its function properly if both the technical and ergonomic requirements have been met. Thus the entry, the processing or storage, and the output of information must take place according to the specifications, reliably and economically, under the working conditions envisaged, and for the designed working lifetime of the system. However, because it is a human extension, it is at least equally important that the system be able to interact with the user, who must recognise and know what informational functions the hardware fulfils and how he can make it work for him. He will have to know how to start the system up and if necessary get the software working, how to control it once it is operating, how to select from particular areas of storage, how to initiate particular routines, and so on. He should be able to play with it as with his own brain – better, in fact, since he will be dealing with even more specialised, specific functions.

At the very least, then, information systems must meet the two following types of condition:

- When the system is being used, the observable processes should to some extent correspond to what operators regard as logical, natural and usual. The system is a machine assisting its user as a quasi-human, thinking, looking up, reporting back, calculating and so on. This demands an absence of strange conclusions, unexpected jumps in trains of thought, inhumanly long waiting periods, illogical questions or superhuman answers. The externally perceivable structure of an information-processing system must therefore correspond to a certain extent to the cognitive and emotional characteristics of its users.
- The system can only function successfully as a human extension if there is reciprocal contact of a variety and abundance such that it may be described as interaction. Contact from the system to the human is by signal transmitters, i.e. displays or information points on the outside of the hardware, and thence by assimilation through the human senses. Contact from the user to the system means that bones and muscles, generally in the arm and hand, in some measure move or rotate a key, button or switch. The operating component on the interface translates this command in some standardised way for use by the internal hardware. Thus the user interface with displays and controls must be adapted to the sensory and motor characteristics of its users.

Our knowledge of human nature is often insufficient for all the technical specifications which the designer of an information system must think of and weigh up. It is true, though, that the science of human factors or ergonomics is beginning to formulate a reasonably complete system of guidelines for adapting machinery and equipment to individual human operational actions or to direct human perception. To a large extent we know how to design a keyboard, choosing shapes, dimensions, colours, movements etc., so that the operator can work as fast, as comfortably and with as few mistakes as possible. The same applies more or less to the design of data presentation as regards character design and size, spacing, layout, brightness, grouping, coding etc. Yet this knowledge is often ignored to the detriment of the ultimate effectiveness and efficiency of the system. The ergonomic design rules for keyboards and screens must also be interpreted, adjusted and combined in a specific and inventive way, depending on the type of information processing or user group concerned. For example, a hotel reservations system and a railway ticket machine resemble one another in only a few respects. So the rules are not so unambiguous and comprehensive that they can produce a complete design, quite apart from the fact there is never just a single perfect solution. Interface design thus continues to place a heavy demand on experience and imagination.

What the ergonomics of design, and the knowledge of human bodies and behaviour cannot yet tell us, however, relates to cognitive and emotional interaction on a higher plane. The building blocks of human perception and operation are merely links in the whole chain of information processing. In many respects the exchange of information between persons can be compared with the interaction between man and information system. One of the preconditions is that there should not only be 'code symmetry' between transmitter and receiver as regards the message to be conveyed and its components, but that there should also be a mutual knowledge of each other's personality and skills in so far as they constitute a meaningful context for an effective transfer of information. At a certain moment there is implicit agreement about the subject of the communication and the rules to be followed by the process of communicating. Sometimes these rules may have broad margins, but excessive violations of them during the communication process lead to misunderstanding and irritation. Transmitter and receiver have a particular picture of each other's conduct on which expectations are then founded. These in turn may lead to a set pattern of interpreting and to redundancy, which permit the interaction a considerable degree of incompleteness and flexibility in sequence order.

How, then, is the information system perceived as a quasi-human being, or, in other words: what is the 'internal representation' that the human user has of the information-processing system? It certainly involves more than the system's vocabulary and syntax. Even more important are the user's expectations regarding the limitations and the nature of the information in the system, and the narrowness and unambiguity, as opposed to the looseness, of the formulation and order of the questions to be asked. In short, it concerns human qualities which the vaguely, ramblingly, emotionally and heuristically thinking user hopes to find in the precisely, linearly, coldly and algorithmically operating information system. The first problem is that it is often very difficult to establish this internal representation, and it may differ widely from user to user. It is a problem that has existed for over twenty years in the case of operators of large control panels in the process industries, and the numerous studies of the problem have produced very little result in terms of producing a corpus of knowledge and methods for predicting this internal representation sufficiently well for it to be taken into account for interface design and hence for the interaction to be appreciably improved.

In other words, it is still not possible to establish clear guidelines for designing the hardware and software of an information system so that the result is a well-mannered and predictable collocutor. Intuition and simulation enable us to arrive at many specific and reasonable solutions, but the risk of mismatching information systems and user groups continues to exist, and with it the risk of incomprehension, irritation and resistance on the part of the user.

There are, however, at least three directions in which these structural imperfections in information systems may be resolved, so there is no need for their designers, manufacturers and users to go in sackcloth and ashes.

The first is that the proper application of the rules of ergonomic design to the interface layout, controls and displays can in itself prevent a great deal of distress. The convenience and clarity of keyboard and data presentation often constitute a good basis from which users can go on to adapt reasonably well to the system's good and bad manners.

Second, one can continue to conduct systematic research into the internal representation of various sorts of information system among various sorts of user group and operating situation. What makes an information system capable of communicating can be unravelled and the appropriate rules assessed by teams of technical systems designers and behavioural scientists. Such an investment in terms of research is also subject to some extent to the laws of the supply and demand applying at a particular moment.

The overall picture at present is that systems designers already have their hands full making information systems operable. As soon as the designer/programmer is able to operate a system he seems to think that will simply have to do.

Little time or attention is paid to ergonomic interface design, let alone adapting it to internal representations. However, once the stagnation in further market penetration has become apparent, we can expect to see those same laws of supply and demand making research into and the design of more humane information systems inevitable.

Finally, a solution may be found in gradual cultural changes. A quarter of a century from now not every possible user of information systems will be an interested information scientist, but by then we can expect the relevant code of conduct to have become far more familiar to a wide section of the population, much as the highway code has over the past 25 years. Experience will gradually grow and improve; general schooling and training for everyday life, of which information systems will be regarded as an indispensable component, willprovide greater insight. This process of accepting the existence of information systems, their usefulness and their curious ability to communicate will have to be based, however, on the progress made in the first two directions.

2.3 Forms of information system adaptation

The perception and assimilation of information can vary within certain limits in one and the same person. Receptiveness to certain sorts of information can increase or decrease while a system is being used, and can fluctuate between sessions of use. This variance is paralleled in the differences between individual users, and the latter is usually even greater than the former, though here too the science of psychophysics has pointed to many limits and natural laws. How, then, is one to adapt an information system to suit changing and different users?

Assuming that the informational characteristics of the user have been established, what systematic adaptability can be built into an information system? Design theory advances three sorts of adaptability: complete adaptability, adaptability to the personality type of the user, and adaptability to the weakest user. Let us examine these three, but without forgetting that many hybrid forms are also possible.

Complete adaptability. Depending on the importance and the duration of an information system it is possible to add a sensor system to detect the degree of difficulty being experienced by the user during the interaction, and immediately to adjust the simplicity of operation and presentation, the size of informational steps in the process, and so on. For example, before he begins the operator may set a multiposition switch on a scale with a number of discrete positions ranging from 'very simple interaction' to 'very complex interaction'. During operation the system then analyses, for example, the accuracy, speed and/or regularity of the user's reactions, or possibly the clarity or ambiguity of his questions and answers. Indeed, it is perfectly possible that the feedback signals would not actually be part of the flow of information itself, but would be such variables as the user's voice pitch, heart rate or muscular tension. In this way the system can adapt itself to changing levels of familiarity with successive subjects, growing fatigue or rising enthusiasm. Because purely passive following is not always perceived as ideal, the user would also be able to control the 'complexity switch' himself, challenging himself to do better or allowing himself an easier passage. However, perfect humanisation has still not been achieved in this possible scenario. The interaction may often be concerned not so much with the quantity of the informational steps as with their nature and direction. To a person whose knowledge of French is poor and whose English is good, switching to English is a better solution than speaking French more slowly. Detection of these differences in orientation is better catered for in the second type of adaptability.

Adaptability to the user's 'personality type'. One might record various important and enduring features of a person's informational abilities, habits and preferences. Just as a person's field and level of education now allow one to predict, to some extent, what one may expect from a conversation with them, so the nature and extent of their experience with information systems could be a coded input signal to achieve a better adaptation between the system and the user. This would work even better if descriptions such as 'low level of general systems knowledge, high level of experience with automatic literature research etc.' could be supplemented by details added by the user himself, such as 'poor short-term memory, cautious, quick on the uptake etc.' When considering this kind of adaptation to information, there is no need to think automatically of complex systems of diplomas, qualifying examinations or psychological tests. However, just as the motorised society brought regulation and it was no longer possible to leave things to the driver's assessment of risks, so the information society will have to develop certain appropriate standards and rules for the benefit of the mutual coherence of the citizenry and their conduct. This brings us to the third type of adaptability.

Adaptability to the 'weakest' user. The whole problem of user affinity in information systems has assumed considerable importance because it is no longer a matter simply of professional and motivated use by a few, but also, and far more, of use by large numbers of laymen whose interest may be lukewarm at best. Information systems in the home, in public telephone kiosks, at post offices and railway stations have the potential to become a boon to society. The automation of information supply is progressing steadily, but with it there is an increasing risk of breeding a growing number of a new kind of illiterate. Information systems with an important role to play in everyday matters like banking, transport and communication must not only be 'friendly' towards the experienced, skilled, clever user, but must also be attuned to the user who is inexperienced or tired or who lacks concentration, and so on. A general rule for designers must be that in the absence of any compelling reason to the contrary, no particular user group may be excluded. Informing those who are less informed is in many cases the criterion *par excellence* of the user affinity of information systems. Should either of the two other forms of adaptability be implemented, these 'weaker' users (at a level to be more closely defined) might form the baseline of adaptability.

2.4 Standardising information systems

The more widespread use of information systems will add a new and important component to our day-to-day environment. When using information systems has become commonplace this will be reflected in our use of concepts, words, signs and symbols. The renewal of vocabulary and methods of presentation is generally a gradual process which is partly spontaneous and partly controlled by science or government. Because we shall be dealing with the transmission, reception, processing and storage of information it is likely that a number of concepts from information technology and programming jargon will enter everyday use. The pre-scientific vocabulary of informational acts naturally relates chiefly to human thought – words like 'calculate', 'compare', 'retrieve' and so on – but it turns out to be ambiguous and incomplete. This is a problem which is beginning to make itself felt in interface design. Controls and displays must enable the user to identify and control all sorts of information flows and processes. In the interests of space and time, if for no other reason, there is a trend towards briefer descriptors consisting of abbreviations, numerical codes or special signs, which appear on and next to keys, on screen, and so on. At present, manufacturers and designers tend to have their own independent solutions, but standardisation of the set of concepts goes hand in hand with standardisation of interface components and the descriptors they use. Both are essential. Clarity, comprehensibility and controllability for the user are among the most important quality requirements of 'humanised' information systems and are a fascinating challenge for researchers and designers.
User Interface Design is beginning to emerge as a new specialism which must and will be able to solve major problems if the coming of the information society is to be realised.

For further reading see: [43, 131-135]

3. Psychological aspects of user affinity: some questions[1]

by Prof. W.A. Wagenaar

This study examines user affinity on the basis of various aspects. Can user affinity be measured directly from the user, e.g. by looking at the degree of mental and physical effort

1. The questions were formulated by the authors of Chapter II

that he has to make. Should such measurements be augmented by subjective observations?

Measuring user affinity by taking physiological measurements will only succeed when we are dealing with extremely unsubtle, coarse examples of user-unfriendliness. These can generally be identified by much simpler methods, consisting as they do of violations of long-established basic rules. Less obvious instances of user-unfriendliness have to be traced by means of efficiency measurements, error registration and subjective assessments of comfort.

User affinity is defined here as the quality of the relationship between man and machine. It therefore depends on the person concerned and on the properties of the machine. Is user affinity also determined to some extent by the way in which an information system is introduced and what guidance users are given in learning to use it?

The answer to that is yes and no. No, because a system not adapted to the user cannot be made more user-friendly by introduction and guidance. Yes, because an inappropriate introduction and poor guidance can still cause problems with a user-friendly system.
At the same time it is necessary at the design stage to try to reduce the need for introduction and guidance to a minimum.
A simple rule of thumb is that the time necessary to get a system fully operational must never cost more then the purchase price of the system. In other words, it must be possible for someone earning Dfl. 150 per hour to learn to use a personal computer costing Dfl. 1,500 in ten hours. If it takes longer than that, there was an incorrect balancing of costs and user affinity at the development stage.

Can the eyes and ears process information simultaneously? Is it a good idea to present parts of the same information to both senses at the same time? A conversation, for example, consists not only of speech but also of non-verbal communication.

It is not easy to increase the flow of information by using two modalities at once. Certainly where two modalities are supposed to work independently, as when we try to read a book and listen to the radio at the same time, major problems are to be expected. Where two modalities are made interdependent, as when we watch a speaker while listening to him, it is not clear what benefit this brings. In the case of signals presented at threshold level, different modalities are well able to support one another, as when we lip-read, but the benefits may be extremely small where above-threshold signals are concerned. The television newsreader is no more easily understood than his colleague on radio.
The chief reason for using more than one modality is that they have different functions. The ears are good at carrying out frequency analyses in the time domain; the eyes are very good at the parallel processing of large amounts of spatial information. What you can show in a picture is sometimes very difficult to translate into an auditory signal with a time dimension. It is important, therefore, to choose the best presentation modality for every kind of information.
For standard references for the use of VDUs see: [123, 136-8].

One constraint on the transmission of information in the form of a written text is that there is no certainty that the reader will understand it. To what extent could interactive operation with the information system eliminate this constraint?

The premise is true to a certain extent. It is indeed possible with an interactive system to clarify poorly understood text by asking for more information, but only if the user is aware that he or she has not understood something properly. The trouble is that problems have a habit of occurring precisely when the user thinks he *has* understood the message correctly, and in that case not much can be expected from compensation.

How can we minimise the need for the user to translate information presented to him by the system so that it accords with his own manner of perception? To what extent can these personal manners of perception (pictures, diagrams or language) lead to specific ways in which the machine should present the information? For example, we have several options when we want te describe how someone should get from A to B:

a. 'right, right, second left';
b. we can draw a sketch-map and show it to them;
c. we can show them the route on a 'real' map;
d. we can explain things narratively, inserting landmarks: 'go past the church and turn left, and then it's just past the hot-dog stand';
   and so on.

Information requires more interpretation the more it is presented in a manner which does not match pre-existing internal representations. This means that the provision of information must always be based on a reconnaissance of the internal representations which people have. This is a standard ergonomic principle which will continue to apply in the future.

How can the credibility of an information system be built up artificially? By redundancy? By testing against other observations? By 'professional' design etc.?

The trouble with information systems is not so much that users underestimate their credibility. On the contrary, they exaggerate it. Systems often radiate so much authority that people are inclined not to ask questions, and neglect to make the necessary checks. This can be countered by making the system rather less obviously authoritative and by occasionally letting it show signs of uncertainty.

4. Natural language facilities in information systems: asset or liability?

by Prof. G.A.M. Kempen

4.1 Some questions[1]

When people communicate with one another there is a continuous process of feedback whereby they can verify whether their messages are being understood and correctly interpreted. This convergence mechanism appears to be essential to being 'on speaking terms'. How can feedback be incorporated into an information system? How can structures be built into the system to provide adequate explanation of its reasoning whenever it is required?

Generally speaking an information system will have various users, each with their own specific cognition. For maximum user affinity a system should be adaptable to different cognitive levels. To what extent can users attune systems to their own level? Could a system detect and adapt to its user's cognitive level automatically?

1. These questions were formulated by the authors of Chapter II

Does user-friendly accessibility require the user to have a conceptual model of the system? Or, conversely, should the system be aware of the inaccurate or incomplete conception that the user has of it?

Is it a practical proposition to set up visual display terminals with comprehensive facilities for information retrieval or extended calculations, for example, without at the same time providing a skilled operator?

Can a user always be expected to learn a control language? If so, he will have to perform the translation from intention to processing (turning his 'fuzzy' problem into a sharply defined and processable question) himself. Should this be a social or educational objective?

Or should the system do it for him, so that it will help him even with his fuzzy problem or sloppy thinking?

4.2 Introduction

Computer programs for processing natural language are written with two objects in mind. In the first place, language processing can be an end in itself: one only has to think of software for the automatic hyphenation of words, spelling correction or (much more difficult) summarising or writing reports. Second, it can be a means to some other end: for example, a data base that can be accessed with questions and commands formulated in ordinary language. There are naturally hybrids too, such as a spelling corrector that automatically copes with typing errors in questions addressed to a data bank.
It is commonly asserted that language-processing software in this second category will enhance the user-friendliness of information systems. Elsewhere in this book there is more than one attempt to seek advantages in 'language technology'. My intention here is to examine how far such hopes are justified. I shall begin with brief resumé of what language processing software can and cannot do, now and in the near future (Section 4.3), and will then turn to the user of information systems (Section 4.4). Will he or she always want easy access to the complete range of means of communication offered by natural language? Or are there circumstances when the user will find a highly formalised language more efficient and comfortable to use, despite its inherent limitations? In Section 4.5, finally, I shall briefly discuss the economic perspectives: user-friendliness does, after all, imply a certain measure of 'budget-friendliness'. I shall be using the term 'dialogue system' to cover all software systems designed to enable linguistic interaction with information systems. (Other terms are 'natural language interface' and 'language front-end'.)

4.3 Dialogue systems

In June 1981 a conference was held in Stanford on 'Applied Computational Linguistics in Perspective', under the auspices of the Association for Computational Linguistics. There a company of American experts with a great deal of experience in the field of applied artificial intelligence and computational linguistics tried to arrive at a considered and realistic scenario for applications of their subject. One of the discussion groups was particularly concerned with dialogue systems, and it is the report produced by this group [139] that provides the basis for this section of my article, since it discusses all the aspects relevant to user affinity. In assessing the comparative importance of these factors I have not simply accepted the views of the group, both because the builders of dialogue systems may be expected to be well endowed with optimism and because the users themselves were not involved in their evaluation.

The report distinguishes three levels of linguistic skill at which dialogue systems may operate. At the lowest level (level 1) we find all the systems currently suitable for practical use, and the few systems commercially available as software packages. Level 2 systems so far exist solely as laboratory prototypes, and work on level 3 systems has only just begun. The report refers exclusively to systems using English. The technology for handling other languages is significantly further behind, with the possible exceptions of German, French, Swedish and Japanese. There are no Dutch-language dialogue systems either in Holland or Belgium, though a project group at the University of Nijmegen is currently working on the construction of such a system with financial support from the government.

The following overall characterisation of the three levels may serve as a point of departure. Level 1 systems offer a basic package of facilities essential to any dialogue system, i.e. modules for:

- the analysis and interpretation of recurrent words, word groups and sentences, especially interrogatives;
- generating sentential answers;
- extending and adapting the dictionary of words and idioms on which questioner and answer generator can draw;
- constructing programs in the formal language (command language, query language, control language) used by the information system.

However, the underlying concept of level 1 systems leads to all sorts of constraints which cannot easily be eliminated, and dialogue systems on levels 2 and 3 therefore had to be constructed according to new principles. Level 2 has powerful methods of solving referential descriptions, level 3 for reasoning about mental states such as goals, plans, and beliefs.

Level 1 systems provide the following facilities. They can:

1. answer factual questions relating to data in common types of data base system;
2. if desired, coordinate data files (e.g. 'What is Smith's location' is translated into 'What is the location of the department of Smith?');
3. resolve simple cases of pronominalisation (i.e. find out what pronouns refer back to; difficult cases are still beyond the systems' reach);
4. handle simple cases of ellipsis (elliptical questions are incomplete and refer back to earlier sentences in the dialogue: 'Where is John?' . . . 'And Peter?');
5. give cooperative answers to 'null-questions' (e.g. to the question 'How many copies of book X have you in stock?' the system might answer not with 'None' but with 'That book is not known to me' or 'That book is sold out');
6. enrich their linguistic knowledge through interaction with the user (e.g. Define 'JD' as 'Jefferson Davis Jones'. Let 'Q1 Smith salary' = 'What is the salary of employee Smith'. 'Q1 JD AGE?');
7. paraphrase input sentences (questions, commands etc.) so that the user has some check on whether they have been correctly interpreted;
8. correct spelling errors.

Some level 1 systems also offer limited capacity for extension, e.g.:

9. updating data according to commands in natural language (e.g. 'Change Bob Day's location to Building 7.');
10. reacting meaningfully to ungrammatical inputs;
11. answering 'meta-questions' such as:
    - 'What information is in the data base?'
    - 'What are the permissible values for employee job titles?'
    - 'How up-to-date are the sales data?'

– 'Can you handle relative clauses?'

The design of level 2 dialogue systems incorporates a system of new principles, the chief of which are as follows:

- the linguistic modules can to a high degree be guided by 'world knowledge' (i.e. a representation of the domain of contents to which the information system relates);
- the discourse context (i.e. preceding questions, commands, answers etc. and their meanings) is retained and exploited to the full;
- input sentences are not translated straight into the formal language of the information system but into a logical interlingua, often a form of first-order predicate calculus (all sorts of linguistic phenomena can now be dealt with in a more general and linguistically more satisfactory manner, so that many *ad hoc* solutions can be abandoned; at the same time the step of translating from the logical interlingua to formal command language is relatively simple).

These new basic principles enable dialogue systems to perform much better in interpreting referential descriptions, i.e. various types of noun phrases referring to objects, states and events in the domain with which the dialogue is concerned. Dialogues systems at level 2 are considerably better equipped to determine the correct reference of noun phrases than their predecessors, as the following examples may show. Suppose a car repair information system is asked: 'If I want to top up the water, where do I find the filler cap?' The decision that it is the cap on the radiator and not the petrol tank is based not on linguistic rules but on a knowledge of cars. Nor can the discourse context be disregarded when it comes to resolving referential descriptions. Take the stock control system of a bookshop when it is commanded to: 'Give titles in stock and prices'. If it is functioning at level 1 the system will produce a complete list of all the books in stock. A level 2 system, by contrast, takes accounts of the content of what has gone before. For example, on being asked 'Do you know any of Graham Greene's books?' the listing produced will be confined to works by that author, and the noun phrase 'the same' in 'And now the same for Ernest Hemingway' will also be interpreted correctly. (This is also an example of the pronominalisation which would stump a level 1 system: 'the same' refers not to an object mentioned earlier but to an earlier sentence in the dialogue.)

A dialogue system at level 3 will be able to draw on an important extra source of information: knowledge of goal-directed behaviour. Starting from needs and goals that it attributes to the user, to itself and possibly to third parties, it will be able to evolve plans and proposals which will as far as possible accord with the interests of those parties. The answers of the dialogue system are based on such plans. Wilensky [140] is one of the first to have started on the construction of such a system. He is working on a 'consultant' which users of the UNIX operating system will be able to call on when they have problems. The chief purpose of the consultant is to help inexperienced users on their way. Here are some question-and-answer examples to illustrate this intention.

- How do I delete a file?
  Typing 'rm filename' will remove the file with filename from your directory.
- How do I change a file?
  Typing 'emacs filename' will get you into the emacs editor.
- What is the best way of making a file?
  The best way to create a file is to use the editor, i.e. 'emacs filename'.
- A directory?
  Typing 'mkdir directoryname' will create a directory with name directoryname in your current directory.

The two central modules in the consultant are responsible for 'goal analysis' and 'plan formation' respectively. When the meaning of the input sentence has been established, the first module tries to recover the user's intention, after which the second module works out a way of achieving this goal. This plan is finally presented to the user in English. For both modules to function satisfactorily they must be able to cope with multiple goals, which may sometimes be conflicting, since the goal foregrounded by a question may contradict objectives which play a part in the background. For example, if the user says 'I'm trying to get some more disk space' the consultant must not come up with 'Type "rm *"', since that advice would conflict with one of the user's presumable background goals by leading him to erase all the data files he has created.

We have now looked at a rising curve of linguistic skills available to dialogue systems now or in the near future. This does not mean that in a few years we shall be able to communicate with computers just as we do with people. Far from it. The concepts underlying the design of dialogue systems have in recent years been improved considerably, and this 'vertical' trend of deepening knowledge will continue in the future. But this does not automatically lead to a broadening of knowledge and skills within particular levels. Modern dialogue systems always operate on a very narrow knowledge base, and extension sideways is no trivial matter. It is labour-intensive because large volumes of knowledge have to be inventoried, analysed and encoded without error. Moreover, it makes heavy demands on external memory, and that can lead to forbiddingly long response times.

4.4 Are dialogue systems user-friendly?

The final sentences of the previous section reveal an important disadvantage of dialogue systems: they prevent the user from seeing their limitations. It does not take long for the user to come up against words, constructions and types of question which the system turns out to understand wrongly or not at all. A dialogue system only becomes user-friendly, therefore, when this 'wall of misunderstanding' is lower than the 'mountain of work' which the user has to get through in order to have an understanding of the information system's own formal language. This disadvantage is aggravated by the fact that users tend to overestimate the system when it has run for some time without trouble. Evidently they apply all sorts of rules like 'If he knows A, he will probably know B too' and then go on to apply them to machines, often erroneously. Verbosity is another disadvantage. Questions and commands in natural language are normally much longer than in a formal language specially attuned to the domain of application. Think of the ultra-short commands in text editors. Dialogue systems are pointless in such areas unless it is as consultants providing solutions to difficult cases and when rare commands are to be used, e.g. 'How do I change the margins?' [139].

The great advantage of dialogue systems is that they can bring about a considerable improvement in the accessibility of information systems. On the one hand the circle of potential users wanting access to the information system may become much wider due to the lowering of the language barrier. On the other hand accessing the system will take up far less time, a particularly attractive point to novices and occasional users unfamiliar with the formal command language, but of less importance to regular and experienced users who may continue to prefer the formal language. The attraction of a dialogue system also depends on the complexity of operating the information system. Another possibility is menu selection, in which the user chooses what he wants to do by using a keyboard (of traditional or specialised design), a light pen, a touch-sensitive screen or a 'mouse'. This alternative is probably more attractive if there are no more than a few dozen different instructions which can be given to the information system, and the user can get to where he wants to be by a limited number of choices (menus and/or keystrokes). Dialogue systems capable of fulfilling a consultant role are likely to be more widely applicable, because they can offer help even to experienced users when they come to areas with which they are less familiar.

4.5 Are dialogue-systems budget-friendly?

Market research has recently been carried out in Germany to establish the possible demand for dialogue systems [141], and there seems to be a great deal of interest in this new technology. Sums of DM 200,000 are mentioned as the maximum investments in purchases or development work. In the United States a level 1 dialogue system has recently been marketed for around $ 70,000, including installation charge and adaptation to the data bank system used by the purchaser. In the longer term, industry in Germany sees the benefits overtaking the costs, and the market survey shows that two types of use hold particularly good prospects. The first of these concerns users without a technical grounding – managers etc. – who need to use an information system for their work. A dialogue system enables them to converse with the information system direct, without the need for intervention by the computer department. For example, a building contractor can carry out and present detailed price calculations even while he is talking to his customer. The second type of use is consulting sources of information, such as literature references on a specific topic, or departure times on an airline's route system, or sources of advice (e.g. to decide which of a particular range of products to buy). I recently saw the following example in the United States. If you want references to literature you are not often allowed to sit down at the terminal yourself, but have to be helped by a special person who is familiar with the formal language and has the relevant keywords in his head. A rudimentary dialogue system – even below level 1 – would be able to take over this task. Systems of this kind are in fact operational in some large American libraries.

The investments required for the acquisition or development of a dialogue system are undoubtedly extremely high, even if one is content to make do with level 1. Even so, the experience gained abroad and described above still justifies the hope that user affinity and 'budget-friendliness' in dialogue systems will eventually be reconciled.

5. Speech technology: an aid to user-friendliness?

5.1 Electronic speech and electronic text: notes on perceptual differences

by Prof. H. Bouma

Now that it is possible to synthesise speech electronically and automatic speech recognition is gradually reaching the stage of development at which it can be put to practical use, it is time to ask ourselves when the interaction between user and information system should use speech and when it should be by visual display unit and keyboard. So far, not much research has been done on this question. However, we can derive some guidance from an examination of the functional differences between speech and text.

Wherever differences are formulated there are also similarities. Both speech and text are forms of natural language, and natural language is almost limitless in the possibilities it offers for human communication. To a large extent, speech and text can also be converted into each other: text can be read aloud, the spoken word can be written down.

Even so, speech and text are frequently not interchangeable. A conversation is different in character from an exchange of letters, a speech is not the same as a manifesto and a lecture rather different from an invoice. Let us look at some of the perceptual differences between speech and text in greater detail.

Speech is volatile and text is semi-permanent. Speech is therefore tied to the moment, and it is at that precise moment that one must listen to it. Text, by contrast, can be consulted at any time and as often as one wishes. Speech messages must be remembered, text makes much less of a demand on memory.

Speech penetrates our consciousness by itself; text requires more conscious attention. If something is said in a moderately quiet environment we hear it, even if we have not the slightest interest in it – we just listen automatically. With text you have to take an active part yourself, even if only to steer your eyes across the page.

Text leaves us free to choose what we want to read; when we listen to speech we have to put up with what is actually being said. And searching for a sentence on a tape is a lot more time-consuming than looking up a passage in a newspaper.

Speaking is fast, writing or typing slow. Even the fastest typist (100 words/min) works at only half speaking speed (200 words/min). Silent reading is even faster (250-500 words/min).

Speaking is easy, writing or typing difficult. The number of people who can speak fluently therefore appears larger than the number who can write fluently. And that is not counting illiterates and children before reading age.

Speaking is sloppy, writing more precise. By sloppy I mean that the rules of the written language (which at the same time are the official rules) have to be observed only to a certain extent. That is why we call much spoken language ungrammatical, even though its meaning can be perfectly plain. It is better, therefore, to say that the spoken language has its own grammar, which is less strict than the grammar of the written language.

Spoken language has personal and emotional colour due to the characteristics of voice and intonation; written language is more reserved and neutral.

Spoken language contains sentence intonation to help the listener determine its meaning. Sometimes, indeed, the meaning is apparent only from the intonation and not from the spoken words. With written language the reader must himself construe the meaning. At the same time, intonation contains clear pointers to the borderlines between sentences and clauses; in the written language these are generally indicated by commas and points.

It would certainly be possible to identify other points of difference, but this is enough for a brief reconnaissance of the field. Let us now turn to the question of how these differences lead to different functions which are in turn relevant to communication between user and machine.

For warnings and alarms one would be more inclined to choose speech. In the event of fire a warning on a screen would not appear particularly effective. But even if the computer is waiting for input a spoken message can be more effective than a message on the screen, unless the user happens to be staring at it. Of course, we can also do both: follow a warning signal with a message on the screen. At least that would stay there to be read, which might be useful if you just happened to miss the spoken warning. When it comes down to it, redundancy is anything but redundant.

If eyes and hands have different tasks, speech is really the only option for meaningful messages – while motoring, when inspecting products, or during a medical examination, for example.

Where large volumes of language are involved one will generally choose text. Text does not easily go in one eye and out the other. It is important that the reader can be far more selective than the listener. That is why one does not leaf through a talking newspaper and cannot so easily go back to the spoken weather forecast.

In situations in which freedom of choice is important, then, we opt for visible text. And if we still want freedom to choose between spoken messages we play a hybrid trick: we choose by eye and by indicating a text we tell the machine what we want to hear. For example, we might choose a piece of music by pointing to the place in the score, or by typing in the number of the relevant bar. But that falls beyond the scope of natural language. In language teaching it is possible to ask for a word to be pronounced by pointing at it (see the second half of this section).

If the message is to be emotional or personal, the choise will be speech. What men, women and children say all looks the same when projected on the screen. Of course, great literature can also be emotional and personal, but that is an indirect process by way of content and not directly from the sound. ' "Scoundrel", he hissed' is always going to be more removed from reality than an immediate slanging-match. There paper and screen let us down.

For learning languages we need both speech and text. Thirty years ago, in the Netherlands, we learned foreign languages chiefly by reading, writing and translating. Less emphasis was placed on listening and speaking. Today language teaching is somewhat more balanced, but even so a direct link between text and electronic speech would be a welcome addition. The language laboratory is something of a roundabout attempt to achieve this. Again, a direct link like this is useful if you want to teach yourself to read in your own language (see the second half of this section).

For rapid interaction, finally, we will always choose speech first. If people are sitting together they do not ordinarily pass one another notes in silence, and typing is as slow as could be. That is why speech is the natural medium for fast man-machine dialogue. A menu on the screen is no more than a miserable derivative, even with a touch-sensitive screen. Another, quite separate problem, is that the information system must be able to conduct a flexible dialogue adapted to human communication, and this is something sadly lacking in existing systems. Insights into how such dialogues must be constructed are now beginning to emerge; they deserve careful attention from designers of dialogue-conducting systems, even simple ones.

What we must ultimately try to achieve is a machine which will be a good dialogue partner in the exchange of information. For this the machine will have to be made intelligent, at least to some limited degree. As a partner in the dialogue it will have to have some knowledge of meaning and associations of meaning, of grammar and of the dialogue situation. This is not merely a matter of the literal interpretation of utterances but also of unexpressed presuppositions conveyed indirectly by means of sentences. To achieve meaningful applications we shall have to find ways of limiting the language domain severely so that it still appears natural to the user. Within these restrictions the insights gained can be implemented, we hope. In the meantime, more theoretical and experimental work will have to widen those insights. It is still a very new field of research and does not lend itself at all to reasoned predictions.

The scope of this contribution is not aimed at providing a complete survey of the subject. It is more important that it should provide food for thought. There are a number of options, and if a choice has to be made it is important not to rely simply on a plausible tale. The reality is usually more complex than it appears from behind a desk. What is wanted, in other words, is more research into actual computer usage.

For further reading see: [142-144]

5.2 The use of speech in language learning

by Dr D.G. Bouwhuis

With all the inconveniences which are involved from time to time in the way humans behave towards one another, the term user-friendly or user-unfriendly is nonetheless inappropriate. The possibilities of human communication, we may suppose, have in the course of evolution been as nearly as possible attuned to understanding other people, and apart from the fact that we are not in the habit of 'using' other people we are, in general, fairly sure of their intentions. These we perceive in two ways. In the first place there is the tradition, both social and personal, of human actions to which we have become accustomed. Then there is natural language, as the most effective means of communication. Both of these factors are completely absent from computers and information systems. The *modus operandi* of an information system, as encapsulated in its operating system, bears no more than a superficial resemblance to human activity, while even the higher-level programming languages, with their exceedingly limited vocabulary and syntax, can scarcely be regarded as even an approximation of natural language.

Designing an automatic system to teach languages is therefore a singular challenge. For the sake of completeness I distinguish here between two forms of linguistic expression – visible text and audible speech. It is possible to display text in a flexible manner on a cathode ray tube, though there are ergonomic objections to this. Textual displays are used by countless teaching programs for larger systems (such as PLATO) and are becoming increasingly common in conjunction with programs for microcomputers, such as those published by the Apple Education Foundation.
This does not detract from the fact that in many situations speech is much more important and effective than printed or manuscript text, as the following examples show.

a. There are many groups of people who can speak and understand speech but find reading more difficult: young children, those with eyesight deficiencies, the elderly, children and adults with reading difficulties, and on the global scale, vast numbers of illiterates.
b. It is the spoken language which we learn first as children, and in immediate relations between people the medium is speech, not writing. Both writing and typing demand so much time that, compared with speaking, they are regarded as either inconvenient or unacceptable.
c. In the case of foreign languages it is a general rule that the sound pattern is unknown. Even when learning to read visual text it turns out that it is useful to have some idea of the pronunciation.
d. When learning new scripts (such as Arabic; or Japanese, Katakana or Hiragana), spoken text acts as an indispensable pronunciation aid which assists decoding.

The research into teaching systems being done at the Institute for Perception Research in Eindhoven therefore pays particular attention to some of these aspects of language which have hitherto been reserved exclusively for human communication. The following four experimental systems are an illustration of the aspect of speech.

Economical coding of speech

The fact that it is now possible to use speech flexibly in computer systems is due to the availability of ways of encoding it very economically. Our own method uses Linear Predictive Coding (LPC) of the speech signal, which is described by a number of parameters (e.g. amplitude, pitch, voiced/voiceless) per sampling period. A signal coded in this way can again be made audible by what is known as resynthesis, thus producing the original speech signal. In general such a resynthesised speech signal is of reasonable to good quality and quite comprehensible. By allowing a limited number of values for each parameter (for example, 30 bits for all the parameters taken together) and by outputting the code with a particular repetition frequency (for example, every 35 ms) it is possible to produce speech with 2000 bits and sometimes even as little as 1000 bits per second. By comparison, a telephone signal, which is somewhat limited in bandwidth, needs some 40,000 bits/sec.

This economical coding allows us to store speech in digital form in the memory of a computer and to reproduce it using a synthesiser. At the Institute for Perception Research this is done with the Philips MEA8000 speech chip developed by the Institute. This chip can only reproduce speech which was originally uttered by a human speaker. Further developments now allow us to produce words and sentences not previously uttered as such, by constructing them of diphones, which are combinations of two successive sounds and roughly describe the speech sounds from the middle of one phoneme to the middle of the next. The process of compiling words in this way is called diphone-concatenation, and it gives the designer a large measure of flexibility in contructing speech messages.

The talking book

There are various ways of storing speech which has been coded in the way described above. One of the earliest was printing on paper in binary code. Assuming that a long word has a duration of 1 second, the complete speech code using bits of 0.2 mm^2 would require an area of approx. 3×10 mm. This code could be read by an optical system. A prototype was constructed using a linear photodiode array of 514 elements. This read the code vertically, and the system was shown to work sufficiently accurately. Its complexity, expense and operating requirements meant that the system was not a user-friendly piece of equipment (though that had not been the primary objective). With present microelectronics it would now be possible to improve this aspect of the system considerably.

Nevertheless, the concept underlying this system does have considerable advantages which are quite separate from the reading system itself. On a page of vocabulary to be learned, for example, each word would be clearly linked to its pronunciation in the cheapest way there is: by printing. Purchase, distribution and storage are all extremely cost effective (it even proved perfectly possible to copy the pages on an ordinary photocopier) and there are no moving parts. Looking up words and sentences and the sounds that go with them would be done in the way people have always been used to, i.e. visually and on paper, and thus requires no new operation to be learnt.

The reading of long words by children with reading difficulties

It is a common feature of children who have difficulty in reading that they can read long words only with extreme effort, if at all. The immediate availability of the sound of the word would appear to be a useful solution.

Because teaching people to read involves only a few words at a time we decided not to use an optical reading system. Instead, there is an electrical contact under each word which only has to be touched with a stylus to produce the sound of the word. In this system speech is coded at 2 kbits/sec, so that the sound of 62 words fits into the RAM of an Apple ™ microcomputer. Once again the sound is produced by the Philips speech chip. With

optimum formatting one 5" floppy disk would be able to carry 10 minutes of speech in coded form.
The conspicuous features of this system are that it needs no training to operate, and that the motivation to work with it is immeasurably greater that with the usual set of printed words by themselves. In an experiment using control groups we found that there was an appreciable difference after one session of 10 minutes every day for three days. After five sessions children able to call up the sound from the computer needed no encouragement whatsoever, whereas children who had to learn without the benefit of sound were almost impossible to motivate. Preliminary results indicate that the speech at will system as now developed leads either to fewer mistakes in reading or to increased reading speed. The beneficial effects are still observable weeks, and in the case of reading errors months, after the end of the experiment.

The talking book: foreign languages

Speech at will was implemented slightly differently with longer texts in English. Speech was encoded and later reproduced by pointing to a word in the current text with a special pen. In this system the paper lies on a special table designed to detect the position of the pen, and it is possible to listen to either the whole text starting from the word indicated or the word on its own. In the latter case there are again two options: the word can be reproduced by itself, without its sentence context, or as it sounds in the running text.
Where blocks of text are read repeatedly the reader almost invariably makes a visual selection. Because of the temporal structure of speech, however, this is much more difficult to put into practice with a tape or record. In the system as described it is now possible to combine listening with visual selection, once again by using a pointing technique. The only difficulty (a fairly minor one) arises when children are instructed to listen to the difference between words on their own and in their sentence context, and indeed this is difficult to hear in the case of long and/or stressed words, in contrast to function words such as conjunctions, articles and prefixes.
High-school children unanimously preferred the speech at will system to a simulated language laboratory. Here it was interesting to observe that the speech at will system was perceived as being better at compelling concentration, even though pupils could indicate what they did and did not want to hear with much greater precision and ease than in a language laboratory. It consequently emerged that in respect of practical listening ability pupils benefited much more from the speech at will system than from the language laboratory.

ELLA - an Electronic Learning Aid

Another very different system is ELLA, which is designed to provide a response to the particular ways in which children learn a language from a textbook which is part of a particular curriculum. In a research project carried out jointly by the universities of Tilburg and Eindhoven, using the facilities of the Institute for Perception Research, a Pascal MICROENGINE ™ microcomputer was used to implement several different learning methods in the same instruction system. The subjects concerned were concepts in context and idiomatic expressions in English.
One learning method consists simply of looking through a list of words with their context and example sentences and marking difficult concepts with a star. Another is a simple self-test in which a word is shown and it is possible to ask for its meaning – rather as one covers up one side of a list of words and their translations. Other methods include a stricter test, or a game in which words have to be guessed on the basis of their spelling characteristics. To a large extent the pupils can determine what concepts they want to look through or study, and they can also call on a dictionary programmed into the system. In the first

version, commands were given with a keyboard, but we have since moved on to touch-sensitive screens. Clear textual indications of what areas of the screen to touch have sharply reduced hesitancy in using the system. This means that the keyboard can be used for its proper task: to type in words and/or spelling forms.
Pilot studies have shown that the user affinity of this system is not simply derived from simplifying procedures. Pupils evidently appreciate having a variety of tasks to perform, each of which is easily carried out and remembered. As regards output, pupils themselves wanted to write or type, and for input many pupils asked for speech accompaniment – a request which is reasonably easy to grant with present technology. In a sense, then, user affinity embraces an adaptation to users' usual potential and actions.

All three projects show how much appeal there is in the use of ordinary speech by computer-based instruction systems and how promising an addition it can be. Another point shared by all three is the response times of the systems involved. The more a pattern of interaction begins to look like human speech behaviour the more users turn out to expect a commensurate response time. In the case of speech this proves to be about 200-300 milliseconds. The extent to which task-specific factors play a part here – such as the pronunciation of a short word as opposed to looking it up in a dictionary – will have to be determined by further research.

For further reading see: [145-147]

5.3 Appendix: A short note on speech technology

by Prof. H. Bouma

The possibilities of speech technology have been growing for some time. A distinction is made between speech production (speech output) and speech recognition (speech input). Speech output may involve a choice from a limited range of speech messages, in which case the resynthesis of speech is a good solution. The messages are first recorded on tape or disc and then analysed to find a way of representing them without using too much memory, usually 4000-1000 bits per second of speech. This is 25 to 100 times more economical on memory space than direct storage. From this memory representation the speech is then resynthesised in an integrated circuit ('speech synthesis chip'). The one-off analysis process is generally supported by improving parts with mediocre speech quality by means of interactive programs. There are various analysis/resynthesis methods, and as they are improved so is the quality of the speech produced. Some systems allow interesting variations, such as varying speed without a change in pitch, and a choice of male or female voice from the same memory representation.

If the number of speech messages to be used is large, it is necessary to resort to a more flexible method of speech synthesis, such as one which allows speech segments to be concatenated. The choice of segments (vocal sounds, syllables etc.) is critical, subject to the constraints of number and the rules needed to make the joins between them sound natural. Some of these rules have still to be formulated and speech quality sometimes leaves much to be desired. For composing longer speech items such as sentences it is necessary to have separate control over intonation and timing, and here too a great deal of research still has to be done. Finally it would be nice to be able to arrive at the speech segment one wanted by starting from the spelling, but this problem too has not yet been solved to satisfaction. All these problems are in principle different for each language. Due to a sustained effort by speech scientists, text to speech systems of acceptable quality are now beginning to appear and it is to be expected that at the end of the eighties all speech messages in many languages will be correctly and comprehensibly synthesised from text.

When we come to speech input or automatic speech recognition we are dealing with quite a different set of problems. Here the chief difficulty is that the way the same message is uttered by different speakers and under different conditions varies so widely that designing a system to identify it automatically as the same message is problematic, if not impossible.

In practice this means simplifying matters by limiting the number of permissible words and training the system by using the speaker who is going to use it. With a vocabulary of say 50 separate words it is then possible to reduce errors to a few per cent, given quiet conditions. If the number of speakers rises or the vocabulary is widened, or if we start concatenating individual words to make compounds or sentences, the problems increase and with them the percentage of errors. An intensive search is currently going on for ways of combining insights into human speech perception and efficient sorting routines. These insights include the possibility of limiting the number of alternatives in the context of the sentence or communicative situation, in itself an extensive field of research in which work is being done at several centres. However, the problems are formidable and in my view it will be many years before large-scale applications will emerge. However, in a limited setting the limited systems that are now feasible can do a reasonable job.

6. The comfort concept

by Prof. I.S. Herschberg

6.1 Some questions [1]

If there is any truth in the thesis that people find that the system they have made themselves is the most user-friendly of all, then the user ought to be able to put some degree of intelligence or creativity into 'his' system. To what extent is this a practical proposition?

'The' user does not exist. An information system has various sorts of user. Should each system have its own fixed classification of users? For example, should we make every system differentiate between professional and non-professional users? Or between regular and occasional users? Or experienced and inexperienced users? Or between the use of the system as an end and the use of the system as a means?

Many input and output devices make a rather primitive impression. Improving them would considerably enhance user affinity. To what extent are there technical constraints to making these devices more user-friendly?

To what degree are the characteristic features of new information systems recognised and to what extent are they exploited? How far do both users and designers start from the environment familiar to them now (i.e. paper, form-filling etc.), so that the old situation is blindly copied into a new environment?

To what extent should a lower limit be set on response times with a view to user affinity?

1. These questions were formulated by the authors of Chapter II

Technology is gradually solving the problem of excessively long response times: can response times be too short?

Can a user be expected to learn to use a control language? Should he be required to?

6.2 Software for comfort

In this article I shall be assuming that 'the' user does not exist. What exists is a number of individual users, each with his or her own perception of the user affinity of the system being used. What is good for one is not necessarily good for another, and it would therefore appear that no more 'mothering' should be built into a system than is strictly necessary. In what follows, therefore, the concept of user affinity or user friendliness with its multitudinous associations has been reduced to the concept of comfort. This is then defined as the whole constellation of provisions contributing to simplification and facilitation, above all of the repetitive operations carried out by an individual user. With these provisions every user can obtain a system that is 'friendly' to him. Some of this comfort can be provided by the hardware. Most of it, however, must be built into the software, and I shall therefore confine myself here to the comfortable aspects of software, on the assumption that the hardware will be suitable for it.
Every user should have access to sufficient working memory, external memory, processing capacity and transmission capacity. This would be a working memory (an area of random access memory) with a capacity of at least 1 million characters and an access time of 1 microsecond, external memory (such as disks) with a capacity of a thousand million characters with an access time of no more than 100 ms, a processing capacity of between 100,000 and 1 million instructions per second and a transmission capacity of at least several thousand bits per second (Viditel with its 1200 bps is at the bottom of the range).

Everything described as comfortable in the following paragraphs can be put into practice in existing systems. Some of them, the large systems only, already have a certain degree of comfort. In the future we may expect these possibilities to be implemented more widely, reaching smaller and more generally accessible systems.

Let us look at three examples which demonstrate what individual comfort is possible even in existing systems. It is a precondition that the system should know something about the user. For example, he may log into the system by entering his name, and if the connection is via a telephone line the system can make a note of his telephone number. The first example is the electronic private branch telephone exchange. Here it is almost always possible to have abbreviated dialling, in which the user only has to dial (or key) two or three figures for a number of eight or fourteen digits. In private exchanges one establishes which numbers are used most often, and these can then be dialled in abbreviated form. In a more comfortable system the short codes can be assigned separately for each telephone set or even for each user individually, who would then be able to determine for himself what code he wanted to use for which number. He would also be able to alter these codes at will. Comfort of this kind could be implemented in existing exchanges with only very slight changes to the software. The main reason why this is not being done is that the exchanges were designed without enough backing storage.
The second example is finding a path in a search tree. Generally the user has a number of fixed initial paths, and at present he must make the system follow each of these from a common origin by giving answers to a succession of questions. In a more comfortable system the user would be able to give each of these paths a name chosen by himself for its mnemonic qualities. Then, if the name were keyed in the system would follow that path without

further intervention on the user's part. However, the user must have an alphanumeric keyboard for this, though it is the lack of suitable software which is the real bottleneck. The third example is the user being able to package a fixed sequence of instructions, no matter how long, in a single 'envelope'. The user can give this 'envelope' whatever name he feels is appropriate. Then instead of entering the same sequence of instructions from the keyboard he merely has to enter the envelope name. Thus all the instructions needed by a word-processing system to close down at the end of a working day can be compressed into a single command, upon receipt of which the system goes through the entire sequence without intervention from the user. What is required for this is a larger external memory, a software-controlled switch and a reset function.

There are many reasons why the potential reflected in these examples, not to mention that of many other elements of comfort, is not being exploited to the full. Chief among them are the following.

- Many systems now in operation are modifications (sometimes hurriedly implemented) of their primitive predecessors, which were central systems without terminals, used exclusively by a system expert who had no objection to complex commands, and who could give the user information by word of mouth and on the spot, should the need arise. Since then systems with terminals scattered throughout an organisation have been introduced, the expertise of the average user has fallen and the user is less inclined to take the trouble to gain more expertise. The increased dispersion (both geographical and intellectual) of users has meant that it is now more difficult to find information when something goes wrong. Thus these barely adapted systems have little by way of user affinity and have little comfort to offer.
- Memory capacity, particularly for internal memory, was initially costly and hence scarce. There was no room to build in a degree of comfort for the user, since comfort makes heavy demands on memory space and other resources such as the character sets and commands that are available. Now memory has become cheaper by a factor of about a thousand and it is therefore a practical proposition to create room for comfortable software.
- In the past, users were more than content if they could persuade the system to perform a task it had been set. The user who demanded comfort had not been invented at the time. The user had to adapt himself to the machine. Quite rightly, though, today's individual user expects the machine to adapt itself to him.

Now it is not my intention to suggest that comfort can be obtained without difficulty. The following are two of the problems which can arise.

- The 'rich man problem'. It is easier to live cheaply if you are rich. The analogy, in terms of software comfort, is that to a certain extent you have to be an expert to be able to use the system in comfort. The user will have to have at least some knowledge of the system in order to set the individual codes referred to earlier and thus to make the system more comfortable for him. To a certain extent this problem can be circumvented by the system administrator, who can estimate what will be comfortable for his users and can offer them certain options.
- The comfort that can be achieved by a certain degree of individualisation requires the system to hold certain information on each individual user, linked to his name. Coding individual search paths fixes the direction of the individual user's interest. Because this means, in principle, that sensitive personal information has to be stored in the system, increased comfort must be accompanied by adequate guarantees of privacy. There is no problem in protecting one user from the curiosity of another, but by the nature of things it is impossible to shield him from the system administrator, the reason being that the

latter not only needs universal access to the system but also makes regular use of that access, usually with the best of intentions. In the final analysis it may sometimes be better to forego a degree of comfort rather than expose the user or oneself to the risk of an invasion of privacy.

We can endorse the thesis that everyone finds the system he has made for himself the most comfortable. We have now seen from the examples that it is possible to allow the user to make his own system.
However, it is necessary to qualify this to some extent. It is not necessary, or even desirable, to make a system extremely comfortable for everyone. If a system does not have to be used by anybody who happens to want to use it, the limited number of actual users will be prepared to make some effort to find specialised information in the system. Moreover the user will then have a sense of pride in being able to handle an intrinsically complex system. Often the information provided by the system will only have meaning for a professional user, such as a doctor using a sophisticated medical diagnostic system. Even if the system is so comfortable that any layman can operate it, it will still not provide him with information he can understand.

The way in which an information system in introduced into an organisation is one of the determinants of user affinity. It is examined more closely in Section IV.3.

If the individual user can shape his own system to some extent it will generally not be necessary to use a fixed user classification. In a system to be used by anonymous users, on the other hand, the practised user may acquire a degree of comfort by introducing himself to the system as having a certain level of knowledge. The same effect can be achieved by programming the system in such a way that it can determine the level of the user's skill from the way in which he answers its questions, and can then adapt itself to suit that particular user. However, the user must always retain the option of escaping from this allotted level and presenting himself to the system as more naive. I therefore regard preselection of user levels as unnecessary in systems with this level of comfort.

Many of the input devices currently available need improvement. The problem is not so much a matter of learning how to work digitally, but of the inflexibility of digital input devices. A multipurpose terminal cannot work comfortably with the system software. However, it is possible in the case of keys with variable functions to indicate what the function is at any given moment, though here again this means extra software.

Even if we can live with the existing types of output device, they still leave a lot to be desired. The resolution of the majority of VDT screens is low, as is the number of lines they can display at any one time. A feasible and more comfortable solution is an upright A4 format with a resolution of a million pixels in colour and the appropriate software. This option is seldom implemented for reasons of cost, and present output devices still tend to rely on outdated formats. Thus the screen line is still largely based on the old eighty-column punched card with no lower case. The electronic form is still regrettably conspicuous for its extreme and cryptic compactness due to insufficient transmission capacity. The CORDA case study provides a good example.

Speed of response need not, *per se*, have any lower limit. At the same time a wide variance in response times is perceived as very unpleasant, and this has led some systems managers to build in an artificial delay which comes into operation when response times threaten to fall below the average, thus making response time appear independent of the system load. This is perceived as pleasant.

The user can be expected to learn to use a control language. In addition to this, the user must supply part of the translation of his problem into the system language. If the system fails to understand him it should guide him with tactful and unambiguous questions. This is discussed in greater detail in Section IV.4.

When one sees how well many children use quite complicated information systems there is some justification in assuming that computer literacy will gradually increase. At the same time, however, user affinity must not be carried to such lengths that those with an insight into computer systems are irritated by their obsequiousness. We have now seen that systems can be helpful to the novice without falling into that particular trap.

7. Privacy

by F. Kuitenbrouwer

According to the apocryphal definition given by Gerald Gardiner, a former Lord Chancellor of England, privacy is 'a conflict between me and myself'. We always want to know everything about other people and at the same time we set great store by the greatest possible reticence when it comes to our own personal details. There is indeed a fundamental ambivalence which has to be taken fully into account when the protection of people's private lives is brought up in the context of 'user-friendliness.'
Certainly it would now be impossible to view the relationship between man and information system without considering the problem of privacy. This was recognised by the Dutch government when it tabled a draft Registration of Persons Bill (Wetsontwerp Persoonsregistratie) [148]. It is as yet unclear whether this extremely comprehensive and complex bill will ever reach the statute-book without major changes. However, it does lay down certain principles which have already received recognition outside the Netherlands:

1. Those registered must be adequately informed about the working of the files in which their details are held.
2. The purpose of a register of persons must be lawful and precisely defined.
3. The data to be recorded must as far as possible be accurate and up to date.
4. The data must not be irrelevant or incomplete for the purposes for which they are being stored.
5. The data must have been collated lawfully.
6. They must not be kept longer than necessary for the purpose for which they are being stored.
7. They must not be used for other purposes or passed on to third parties without the consent of the person involved or a competent authority.
8. Special safeguards are required for the storage of certain categories of sensitive information.
9. Files must be adequately secure.
10. The persons involved are entitled to share access to and if necessary correct the information held on them [149].

For the implementation of these principles the reader is referred to the so-called privacy regulations provided for in the Bill. Here the Bill endorses the guidelines previously issued for the civil service [150]. An increasing number of data banks have now established regu-

lations. This is a typically Dutch note in the international concern for the protection of privacy.
The chief points of a set of privacy regulations are as follows.

1. A precise definition of the purpose of recording personal data.
2. A precise definition of the sort of data being recorded about what sorts of person.
3. Provision for the periodic erasure of data.
4. A description of the organisation of the system, with the stress on management (plus any further guidelines relating to the technical organisation).
5. A description of those to whom data are passed and a statement of what sorts of personal data may be passed to each.
6. Regulation of the right of persons involved to see, and if necessary correct, the information held.

When regulations are drafted a number of choices have to be made [151], though particular mention must be made of the problem of internal and external checks on the implementation of the privacy rules.
As the list shows, the emphasis in the privacy rules is on the recording of personal data in files. However, due partly to recent developments, growing attention is being paid to the stages of the information process which precede and follow actual registration, namely the collection of data and the use which is subsequently made of them. On the first point one might think of measures to ensure that personal information is obtained directly from the person concerned, wherever possible, that when the information is asked for the subject is told what it will be used for, how it will be stored, and whether or not answering the questions is obligatory (and if so, what the consequences of non-compliance will be).
The growing interest in the use of personal data reflects the realisation that they are not divorced from, but derive their significance from, the context of decision-making about individuals. A recognition of an individual's position in law does not, of course, mean that the person concerned must always be allowed to have his way, but the transparency of the decision-making process should be improved. One might, for example, think of an obligation to give reasons for unfavourable decisions, together with a statement of the information upon which those decisions are based. An extension of this might be a right of appeal.
As regards the use of personal information, we could consider a West German idea known as *Informationsgleichgewicht*, which may be roughly translated as the usability of an information system by those who are documented in it. This concept has been implemented far less than privacy in the sense of a defensively tinted concept (as in privacy regulations), but it can nevertheless be seen as a cornerstone of a 'citizen-friendly' architecture for information systems. A link between the two concepts is provided by 'access', both in the form of accessibility of a system to the data subjects, and in the sense of the openness of government (or management). Another important point is the extent to which the system design addresses itself not only to questions posed by primary users but also to those asked by data subjects. Here there are questions (which still need answering satisfactorily) on the degree to which those concerned have a say in what takes place. One of the principal tests for the *Informationsgleichgewicht* is whether the system not only has a regulatory or monitoring function in respect of those in the file, but also in respect of the users for whom it was designed. For example, is a computerised file of medical records also of service when it comes to matters of identifying and dealing with cases of malpractice? Clearly, this is where the ambivalence of the notion of 'user affinity', to which I referred earlier, comes fully into the spotlight.
Finally, there is the question at the 'macro-level' of whether a particular practice or system of registration ought to be allowed to exist in the first place. There are almost no hard facts

on which to judge this problem, and this is undoubtedly tied up with the persistent notion that data processing is nothing more than a product of a particular task, unlike, for example, the financial or personal aspects. Nevertheless, an integral question in all work associated with managing people or things is: how dependent do we wish to be on information technology?

8. System user-friendliness in organisations

by Prof. T.M.A. Bemelmans

8.1 Introduction

'User-friendliness' is a term used indiscriminately in connection with computerised information systems. Very often what is meant by it is the complex of requirements which a system must fulfil on the plane of the man-machine interface. Here I shall be placing user-friendliness, or user affinity, in a rather wider context by discussing the various performance requirements which a computerised information system must meet if it is to function successfully in an organisation, followed by the requirements imposed during the development of such a system. The first sort of requirement, then, has to do with the system as the end product of a development process, the second relates to the development itself. It should be noted that, in the context of information systems, development means the design, construction (including programming) and implementation of a system.

8.2 Requirements for information systems

When considering an information system a distinction should be made between functional requirements and performance requirements. Functional requirements determine what sort of information has to be provided for what purpose. Performance requirements, on the other hand, determine the conditions which have to be met before information is supplied. Let us briefly examine both sorts of requirement.
There is little to be said here about functional requirements. An information system serves to support decision-making and action-taking within an organisation. This implies that there must be a high degree of congruence between the decisions and problems of execution on the one hand and the information system on the other. An information system which is not perceived as being a real aid in decision-making or action-taking is not user-friendly but is superfluous ballast and a hindrance.
A recent article [152] lists 39 criteria by which users are able to express a value judgement concerning the information systems available to them. Only three of these criteria have any direct bearing on the matching of decisions and actions on the one hand and the information required for them on the other. The three are relevancy, perceived utility and confidence in the system.

Turning now to performance requirements, the department of Business Management at the University of Technology, Eindhoven, has done and is still doing some quite extensive research on the subject. In essence it is the performance requirements which determine the quality of an information system [153]. It has been found useful to classify performance requirements in five main groups.

1. *Effectiveness*. This main group comprises a number of subsidiary requirements concerning time and quantity aspects and matters like integrity and security.

2. *Efficiency.* An information system must be structured in such a way that there is equilibrium between benefits and costs.

3. *Durability or time robustness.* An increasingly familiar feature of the literature is a plea for the development, using program generators, of 'disposable' software. Although the future will undoubtedly bring this kind of development, designing and making software is currently a labour-intensive, costly operation. For the time being, then, people will continue to keep their systems going for as long as possible.

4. *Degree of integration.* Organisations commonly have not one but several information systems. However, since they are not and cannot be perfectly independent of one another, they must be adapted to each other and thus to some degree integrated.

5. *User affinity* at the man-machine level (here treated as the first level of user affinity).

I shall examine each of these main groups of performance requirements in the following sections. They are summarised in Table 1 at the end of the article.
First, however, the following points should be noted. Not all the main and subsidiary requirements listed in Table 1 will be equally important in every application. Thus the protection of privacy may be paramount in one application and quite irrelevant in another. The requirements listed in Table 1, therefore, cannot simply be imposed on any information system. For every application it will be necessary to consult those concerned and discover which requirements are relevant, and to what extent. Information analysts play an important supportive role here. Compiling the list of requirements for an information system is not a simple, straightforward process, but a constant weighing of wishes and their implications. For example, the wish to keep response times at or below one second may necessitate a considerably more costly system than is really needed for the purpose. When designing a system the information analyst cannot ignore this kind of choice. If he does, he behaves not like a designer but like a sort of waiter who, uncritically and uncreatively, notes down all sorts of wishes, wise and foolish, expressed by users, and by doing so creates the impression that everything is possible at negligible cost and effort. It is for this reason that it cannot be stressed sufficiently that an information analyst must provide users with *creative partnership.*

8.3 Effectiveness and efficiency

Almost every study of the development of information systems contains the maxim that efficiency must go hand in hand with a critical cost-benefit analysis. In practice, though, it is exceedingly difficult to set up a meaningful cost-benefit analysis, certainly where the various performance requirements have to be weighed against the concomitant effort and expense. I touched on this when I stressed the crucial role of the information analyst.
The requirement of effectiveness can be implemented in a large number of sub-requirements, including the following.

- Time criteria such as response time, actuality of data and the timeliness with which they are supplied, something which is determined by the potential frequency of information processing. Clearly, supplying information at the wrong moment, whether too early or too late, is going to irritate users. As for response times, empirical research has shown that these should rarely or never be longer than two seconds, since users then start perceiving the system as extremely slow and thus irritating. There are exceptions, as when a great deal of 'number-crunching' has to be done, when users regard it as quite acceptable for response times to be lengthened. Even so, progress reports are perceived as very welcome in such circumstances.

- Volume criteria and complexity: the amount of data for input, the amount of output and the volume and complexity of files and applications programs. Taking output volume as an example, systems which allow users to call up data selectively are perceived as being more user-friendly than those that do not. In this connection it is advisable when designing systems intended to support decision-making and action-taking to build in options for the aggregation and disaggregation of data, for the selection of data (e.g. for management by exception) and for what is known as 'zooming' (presenting increasingly detailed information at each step of a structured request for data).

- Integrity of the system components, i.e. hardware, software, data and procedures. The integrity of the system includes sub-requirements such as:
  - reliability of hardware and software. This can in turn be subdivided into reliability, availability and correct operation of hardware, software and manual procedures. Availability depends on such factors as down rate, degree of redundancy (i.e. duplicated hardware) to be called on in the event of a fault, and repair and maintenance times.
  - accuracy and completeness of information. Information must be both accurate and complete and at the same unambiguous and consistent. Inconsistent data are fatal for the users' confidence in an information system.

- Security. The security aspect covers all sorts of measures to prevent unauthorised use, alteration or destruction of data. There are various method of encrypting data, making access to data subject to identification and authorisation procedures (e.g. passwords, voice or fingerprint recognition) and validating and (sometimes automatically) correcting input data. Making information systems secure is an area which has received a great deal of attention in recent years due to the controversy about the right to privacy, a subject tackled elsewhere in this book.

This brief summary of the effectiveness and efficiency criteria applicable to information systems is intended merely to give a general impression. Readers requiring a more detailed discussion of the subject are referred to [153].

8.4 Degrees of integration and durability

The degree of integration of a system is an indication of how far the various 'component systems' within an organisation are designed to work with one another and can thus form a 'total system'. It also refers to the extent to which parts of an information system fit in with the structure of the organisation (the organisational fit).
The reason for distinguishing between different systems within an organisation is purely pragmatic. It has become apparent that in practice the idea of a single all-embracing 'total system', used by all the functions and all the departments of an organisation, is an illusion. That kind of approach merely silts up due to excessive size and complexity, so that it is preferable to divide the whole thing up into manageable partial systems which can be implemented within acceptable throughput times. However, dividing the system up like this does require a clear information processing architecture if it is not to degenerate into 'islands of computerisation'.
An approach of this kind also requires new agreements on data definitions and codings, and design methods and documentation. I shall return to this in my discussion of comprehensi-

bility and compatibility in Section 8.5.
Experience has shown that the greater the use which different departments have to make of the same system the more likely it is that the decision-makers will find the system too complex and too anonymous. This became abundantly clear when the first centralised data banks were introduced and attempts were made to put all the relevant data in a single large data bank. Such systems seldom succeed because they become unmanageably complex.
The last aspect of integration that I wish to discuss here is the often poor compatibility of sub-systems with each other and with successive systems. It is by no means exceptional for the output of one system to need reshaping on new disks, tape or punched cards before it is suitable for processing by the next system, and this, not surprisingly, is regarded by users as particularly user-unfriendly. Once again, this kind of situation can only be avoided if computerisation takes place within an overall concept, laid down in an architecture.
The durability, or time robustness, of a system is another of the prime requirements concerned with user affinity. One of the factors affecting a system's durability is its flexibility. There are two kinds of flexibility: narrow and broad. Flexibility in the narrow sense is the degree to which an information system can cope with exceptional circumstances without needing modification. One part of this is the system's ability to deal with errors. Obviously users are not going to regard a system as user-friendly if everything grinds to a halt as soon as an input error is made. More or less the same applies if a system cannot cope with 'unusual' situations such as goods being returned, special discounts and so on.
Flexibility in the broad sense is the degree to which a system can be adapted and expanded with relatively little effort and at relatively little expense. It is normal for users, once they have learned to work with a particular information system, to shift their need for information to a higher level. In other words, they want to do more with the system than it was originally designed for. Flexibility in the broad sense is determined by such things as the expandability of both hardware and software, and by compatibility. The expandability and compatibility of software are chiefly determined by modular program design, clearly structured and documented programs and the use of standard programming languages.
It has recently become possible to improve general flexibility by an approach to system development known as prototyping or evolutionary software development. This requires the availability of a considerable arsenal of utilities such as program generators, debugging and editing facilities, and data dictionaries. These make it fairly easy to replace an outdated system with an adapted and improved version. There is then no need to anticipate information requirements in four or five years' time. Growing needs can be met rapidly by generating new system components or even by replacing the entire system with a more extensive version.

8.5 User affinity in the narrow sense

As Table 1 shows, one of the main performance requirements is user affinity in the narrow sense, which itself can be subdivided into various subordinate requirements. One of these is that the system should be easy to use. Ease of use covers a number of ergonomic aspects and the conditions in which the operator has to work (space, light, temperature, etc.). All these aspects are dealt with elsewhere.
Another of these subordinate requirements is that the system be comprehensible. The structure and design of an information system must appear to its users to be logical, particularly as regards those parts of the system with which users have to work most frequently, such as input, output and file organisation.
As far as the last of these is concerned, it is becoming increasingly common for the data structure to be shown in what is called a conceptual scheme, possibly divided into various sub-schemes for each of the main groups of users. A conceptual scheme shows users what

data and relationships between them are stored in an information system, and it does so in a way they can understand.
Comprehensibility also includes the precise definition of the significance and meaning of the various sorts of data. People in an organisation cannot work together if they are all speaking their own languages. In practice this aspect is all too often glossed over. Everyone defines his own data, and the result is a series of 'islands of computerisation'. For example, in one quite large company it emerged that there were no fewer than twenty-four different current definitions of 'product stocks'. The resultant confusion may be readily imagined: everybody had different stock figures, not because of incorrect or unpunctual processing but purely and simply because everybody's definition of stocks was slightly different. And if there is one thing calculated to undermine confidence in information systems, it is inconsistent data.

By now it will be clear that defining data precisely and coding them uniformly are extremely important in an organisation. Nor is this by any means a sinecure, if one considers that almost any organisation has to deal with thousands of pieces of information. The result has been the creation of a new function, namely that of the data base administrator, whose responsibilities include designing and updating standard definitions for the information in an organisation, and managing that information.
Other functions in an organisation concerned with standardising the 'language' used are those of the various coding operations (e.g. allocating customer and article codes), the project librarian, who is responsible for the uniform documentation of systems, and departments to set up the necessary procedures, e.g. input procedures (laying down who is responsible for accurate and punctual input), processing procedures, and output procedures (laying down who must provide which persons with what data at what time).
The third and last subordinate user affinity requirement I wish to discuss here is learnability. An information system must never be confined to only one person, even if only to avoid the whole system having to close down if for any reason that person happens to be absent. Whether or not a system is easily learned is largely determined by the clarity and reliability of the system documentation, and here again it is necessary to come to clear agreements as to the 'language' to be used, i.e. to which standard the documentation will be designed. Content, layout and make-up of the documentation cannot simply be left to the arbitrary insights and preferences of individuals within the organisation.
Although everyone places great emphasis on the importance of good documentation, it is conspicuous that in reality nothing much seems to come of it. Indeed, it is not even exceptional for systems to be supplied without any documentation at all, generally because of poor organisation while the system is being set up or for dealing with changes in a system once implemented. Systems analysts and programmers often delay documentation until the job has been finished, and what is put off is sometimes put aside. This is one reason why modern methods of developing information systems allow for documentation during, rather than after development, so that system developers are more or less obliged to document the system step by step. Once the system has been implemented the organisation should have adequate alteration procedures, of which updating system documentation should be an inalienable part.

8.6 User affinity in system development

There are countless different more or less 'official' ways of developing information systems, each with its own particular emphasis. Nevertheless, one characteristic of many methods is that inexperienced users are suddenly faced with what is to them wholly incomprehensible computer jargon. There are few methods which employ procedures and a 'design language' such that there can be any really participative approach, in which users not only have a say in what system should be developed, but can also indicate, at the initial stages of development, what can and may be computerised. This results in a logical design which specialists can then use to shape and work out the system further. One of the methods perceived as user-friendly is the ISAC method developed at Stockholm University [153-155]. It is not as curious as it might seem that methods which devote considerable attention to the participative approach should come from the 'Scandinavian school', since it is in the Scandinavian countries, in particular, that employees and trade unions have a statutory right to a say in the development of information systems.

As regards the degree of participation the literature is concerned with three main variants:

- consultative design: the design of an information system is produced and 'sold' by specialists in the field after some consultation with those involved (user interviews). The authors of the ISAC method refer to this as the expert strategy;
- representative design: here the broad outline of the design is drawn up by representatives of the user organisation. Information specialists play the part of a catalyst in this process and are also responsible for the technical design;
- consensus design: here design decisions are taken by all concerned. A team of designers, consisting of users and specialists, then works out various alternative implementations of these decisions, after which all concerned again have to reach a consensus on which to choose.

Although the last of these strategies most closely approaches the ideal of participative design, and in this sense will be most likely to make a positive contribution to acceptance, it also has its disadvantages. For example, the design process is likely to take longer and will require a great deal of effort to organise. Furthermore, consensus design only really works in the case of changes in working methods and procedures which do not require major organisational or other adaptations, such as a drastic cut in staffing levels. It is hardly likely that those involved (i.e. the victims) will be keen to agree to computerisation projects designed to reduce numbers of employees.

In the article by Bailey and Pearson [152] to which I referred earlier, a large number of criteria are named as determining whether or not users perceive system development to be user-friendly. The authors mention top management involvement, organisational competition with the EDP department, relationship and communication with EDP staff, the technical competence and attitude of EDP staff, the order in which EDP projects and services are tackled, the time required for new development and the implementation of change requests, the determination of priorities, the charge-back method of payment for EDP services, and vendor support. Empirical investigation has shown that the most important of these are the technical competence and attitude of EDP staff, the determination of priorities, the time required for new development and change requests and, last but not least, participation.

As regards participation, it is likely that much will change in the development of information systems largely as a result of the prototype approach mentioned earlier. At the same time the ideal is still to create aids for system development such that even users with little experience of computers will be able to define and generate their own systems. This will eliminate the need for the majority of the 'middlemen' in the process, i.e. the specialists, most of whom actually tend to cause bottlenecks and delays. They will then have to reorientate themselves on other tasks, such as ensuring an adequate information infrastructure, including shared data banks and networking facilities, and the coordination of system

TABLE 1 SUMMARY OF PERFORMANCE REQUIREMENTS FOR AN INFORMATION SYSTEM

EFFECTIVENESS	EFFICIENCY	DURABILITY	DEGREE OF INTEGRATION	USER FRIENDLINESS in narrow sense (first level)
1. *Time requirements* (response time, actuality or currency of information, timeliness and corresponding frequency of information processing and delivery).	1. *Efforts and costs* for the development, conversion and implementation of the system itself.	1. *Flexibility* and the corresponding stability of business processes.	1. *Organisational fit* (modularity of systems corresponding to the business processes).	1. *Ease of use* and environmental conditions (convenient and efficient means of input and output, error recovery of user mistakes, convenience of access, easiness and power of language).
2. *Volume and complexity* (aggregation and disaggregation, selection, zooming).	2. *Operational costs* of the system including maintenance costs.	2. *Maintainability* of system (data files, programs, procedures).	2. *Uniformity* of semantics of data and programs.	2. *Understanding* of the system (data structures and programs).
3. *Integrety* (reliability. accuracy, completeness, precision, consistency).	3. *Organisational costs* (costs of adapting the organisation, introduction costs, costs of training and learning).	3. *Adaptability* of the system.	3. *Standardisation* of design methodologies and system documentation.	3. *Learnability* (degree of training, quality of documentation).
4. *Security* (protection against misappropriation or unauthorised use, alteration or loss of data).		4. *Extendability* of the system.	4. *Compatibility* of data resources.	
		5. *Compatibility* of the hardware and software.		

development from an overall architecture for information processing and computerisation.

9. User-friendliness as the OEM sees it

by Dr H.G. Boddendijk

9.1 Introduction

In this article I shall examine the concept of user affinity in information systems from the point of view of the manufacturer of hardware and software, or OEM (Original Equipment Manufacturer). I shall also be looking at the demands coming from users and some trends in user circles. My main intention is to take a pragmatic view of user affinity and how it is likely to evolve in the office of the future.

9.2 Definition

OEMs have to deal with the following classes of user:
- management;
- computer professionals;
- applications specialists (secretaries, accountants, etc.)
- professional but not computer-specialised users ('computer laymen').

For the first of these groups user affinity is chiefly important in the context of such features as:
- price/performance ratio
- operating costs
- integrability in an organisation
- integrability in an existing system
- compatibility with existing systems and applications software libraries
- facilities for communicating with other systems
- simplicity of installation and after-care, both hardware and software
- high degree of availability (low down rate).

For the other groups the concept may be specified as follows:

- computer specialists and system designers need:
  - a wide range of hardware applications
  - powerful development, testing and documentation utilities
  - compatibility with preceding and succeeding systems
  - hardware-independent software
  - data base support
  - communications facilities

- the applications specialist wants:
  - concrete support for the work in his special field
  - dedicated hardware designed according to ergonomic principles
  - ease of data entry
  - user training
  - comprehensible documentation.

– the non-routine user, the layman, has the following requirements:
  • multifunctional hardware
  • standardised software
  • transportability
  • extensive operator support
  • user training
  • comprehensible documentation
  • easy creation of files
  • industry standards (so that use can be made of an outside software library, for example)
  • hardware whose exterior design, facilities and simplicity of operation appeal to potential users and which at the same time is ergonomically designed

9.3 How important is user affinity to the OEM?

Table 1 shows the market for information systems, broken down into general purpose main frames, small business systems and terminals.

Table 1. European market for information systems

	1982		1987 est.	
	number	value in 10^9 US \$	number	value in 10^9 US \$
main frames	6,850	7.4	13,900	16
small bus. syst.		4.1		10.8
workstations (annual increase)	800,000	3.3	2,500,000	9.7
workstations (total)	2,000,000		8,000,000	

Source: *Quantum Science*

It is clear from these figures that the number of office workers using information systems is going to rise appreciably.

Closer analysis of the figures for workstations produces the results shown in Table 2.

Table 2. Penetration of workstations in Europe

	1982		1987 est.	
	tot. number (× 1000)	penetration %	tot. number (× 1000)	penetration %
Management	65	1.1	604	8.8
Technicians	321	3.2	2,410	20.1
Secretarial staffs	132	3.7	874	24.3
Others	1,480	10.9	4,980	36.4

Source: *Quantum Science*

Most of this growth will be accounted for by people who are not computer specialists. No manufacturer wishing to keep or enlarge his share of the market will be able to ignore their requirements.

Users have the following order of priorities.
1. System reliability and good service.
2. Simple operation and multifunctionality.
3. Availability of standardised software packages.
4. Expandability.

It is interesting in this connection to discover whether user affinity is a market argument. The answer is that it is, since the person who is actually going to use a machine is increasingly involved in the decision-making process when information systems are to be purchased or replaced.

9.4 What can OEM and user do?

The OEM can take the following steps to provide an adequate response to users' requirements:
- he can involve users and ergonomists in the process, starting at the design stage;
- he can build up applications knowledge for the development of hardware and software. This knowledge will be determined not by what is technically possible but by what the application demands;
- he can carry out test projects, conduct test marketing and set up user clubs in order to gain feedback from the field.

Clearly, the OEM on his own is not likely to produce the products people want. The user plays an important role, and he will also profit from an in-house user group which evaluates the use of the system, maintains contact with similar groups outside the organisation, and exchanges experiences and information with the supplier. In this way the manufacturer in turn is encouraged to produce innovations.

9.5 Some forecasts and speculations

In the rapidly growing market of the coming years, and with a number of new user categories, every manufacturer will have to do his best to improve his competitive position: market shares have yet to be apportioned in the new segments.

One important aspect of competition between manufacturers is overall operating costs.
- Purchase prices will fall due to increased production volume, more advanced electronic integration and improved efficiency in production and distribution.
- Maintenance costs will fall due to improved reliability resulting from hardware component redundancy and diagnostic aids (such as testing from a distance).
- Requirements for operating environments will almost disappear, especially as regards workstations, thus making over-the-counter sales a viable proposition and ultimately leading to lower costs for the customer.

User affinity will be just as important. Manufacturers will have to address themselves to the following points:
- new, higher-level programming languages and program generators;
- comprehensible user documentation;
- software for hands-on training and self-explanatory help programs;

- improved methods of data entry: optical character reading, image reading, voice input, etc.

In addition to the features listed above, users (particularly users in the new categories) want simplicity of operation, multifunctionality and ergonomic hardware design and construction. Managers want terminals with the following functions:

- the ability to send and receive messages, both text and speech, via public networks to and from outside subscribers;
- local storage processing (personal computing), chiefly aimed at modelling (spreadsheets) and business graphics; supporting functions such as a diary, meetings planning, rough files for short notes and *aides-mémoire*, storage of telephone numbers and automatic dialling on entering the name of the subscriber wanted, and the indexing, storage and retrieval of documents in personal files;
- communications functions for data, text, speech and graphics, both with an in-house main frame or other workstations and with the outside world, i.e. other office systems and public services.

Simplicity of operation will be achieved through more widespread use of the following features to simplify the interface with the user:

- HELP keys
- menu-driven programs
- soft (i.e. user-programmable) keys
- 'mouse'-oriented operation
- touch-sensitive screens (these and the mouse helping to reduce reliance on keyboard skills)
- self-explanatory training software and documentation
- telesoftware and telesupport
- integrated packaging (systems disguised as an entity of hardware and software, like the Apple Lisa).

All the above features of multifunctionality and ease of operation are now at a more or less advanced stage of development, and some are already on the market. Since no manufacturer can afford to ignore the wishes of the user, introduction of the remainder would appear to be only a matter of time. This process could be speeded up or improved considerably if user groups pooled their experiences and provided OEMs with practical experience of their present systems – experience which can then be put to good use in the design and development of the successors to those systems. In all this the user must bear in mind that user affinity and usability are chiefly a matter of software which, if justice is to be done to it, requires more powerful hardware and a concomitant increase in relative price.

10. User affinity and the democratic imperative

by Prof. S.J. Doorman M.Sc.

10.1 Some questions[1]

Working with an information system demands a certain degree of adaptation by the user to the system, whether by a particular course of training, brief coaching or a gradual adjustment to the necessary way of working and thinking. As far as young people are concerned this does not appear to be a problem, even now, and in the schools and colleges of the future information systems and working with them will be a regular feature of the curriculum.

However this development may create problems for older people, and indeed not only for them. It is conceivable that people who are not brought into contact with information systems during their education or at work may begin to form a new class of illiterates. What would be the social and ethical consequences of this? Would there be a parting of intellects (privileged and unprivileged)? Is it possible that the same problem will occur in a more highly differentiated way as a result of the extraordinary rapid technological advances, producing a class of leaders, a class of those more or less left behind, and a class of illiterates?

We often regard user friendliness as a concept which produces requirements which the system must meet. In other words, we tend to adapt the system to suit the user. But there is also such a thing as 'computer literacy', where the emphasis is on the other foot: the technology exists, and it is up to the user to learn how to get on with it. How far should we go in adapting the system to the user? Should we necessarily go as far as we can? What are the factors on which the answer to this question depends?

People are used to turning to other people with many sorts of questions and problems; it is part of our make-up, as it were. What are the consequences if the collocutor is replaced by an information system? To what extent should the machine resemble, or imitate, a person? In what respects should it not? Are there historical parallels from which we can learn?

Will there be increasing alienation as machines begin to look more and more like people (with 'intelligence' and 'senses')? If so, would this not constitute an upper limit for user-friendliness? (Ultimately it might be a matter of the recognisability of the machine as a machine.)

Information systems enable us to store and retrieve vast quantities of information. Does this increased availability of information erroneously suggest that it leads to better decisions? The semblance of knowing everything and controlling everything? (Overestimation of the meaning of quantity; no improvement in quality.)

The first 'information system' with which a person communicates is another person (parent/guardian). The first communication is without language and is to some extent independent of culture. This presupposes a set of innate communication procedures which we extend and develop during our lifetime. The question is how far it is possible to make good use of these communication procedures. For example: information on a state of affairs can be expressed by a representation of human facial expressions.

Human evolution has taken us from non-verbal communication, through speech and listening, to writing and reading. The evolution of the machine has run in exactly the opposite direction. Now that communication with machines by way of speech and listening is gradually becoming a technical possibility, machines are beginning to look increasingly like people. The following questions present themselves. To what extent will people accept talking to machines and having machines talk to them? How will the process of habituation to verbal communication with machines take place? Will verbal communication with machines recoil on ordinary language?

10.2 A discussion of the problem

Even a brief inspection of this treatment of the subject is enough to make it abundantly clear that it is extremely difficult to get a grasp on the problem of user affinity. This is especially true if we try to imagine how things will actually develop in the future. Moreover the question of how far we can influence those developments is particularly complex. In explanation of this fact there are at least two observations to be made.

1. Cultural philosophers try with persistent regularity to design 'grand visions' of the future. Yet it is evident that in these speculations about the future we are capable of making enormous mistakes, witness Herman Kahn's picture of the future, written in the 1960s, in which there is no mention of microelectronics or their technological and social consequences.
2. A more fundamental difficulty lies in the absence of a natural link between our rational potential for analysis and our intuitions about the values involved in the user affinity problem. Rational potential for analysis generally concerns the question of how far different means are appropriate to a given end. In principle, scientific methods supply the means of answering such questions. The question of which ends we should be choosing leads us onto the field of values, and our philosophical tradition has shifted this question of choice precisely to the domain of the irrational (cf. philosophical clichés such as 'chacun a son goût', 'there is a difference in principle between values and facts'). In other words, we have learned to believe that the possibility of judging things scientifically has little to do with value judgments, whereas when we talk about 'user affinity' or 'user-friendliness' we are dealing with both. Unfortunately our cultural anthropological insights are too limited to allow us to carry out an adequate correction of the way we think in such matters. The origin of this problem is deep-seated, and has implications which go beyond the possible integration of the use of information systems in our human reality. Let me make a few general observations on this point.

It has become something of a commonplace to observe that in our western industrial society there is a cultural crisis relating to the role of science and technology. In recent decades the problem has been identified as equally important by widely differing schools of philosophy (see J.H. Habermas, a representative of the Frankfurt School, and H. Putnam, a major exponent of the philosophical traditions of the English-speaking nations). We are evidently not yet capable of giving an adequate analysis of the cultural and social role of science and technology, and this incapacity may have something to do with the cultural historical observation that science and technology have had a far-reaching influence on our ways of looking at 'rationality'. Logical positivism, a philosophical tradition closely bound up with science and technology, constituted the philosophical confirmation of the thesis that all our judgment outside the domain of those founded on science and technology are wholly irrational. By restricting 'rationality' to mean 'the rationality of science and technology' it turns out that discussions on such matters as the social relevance of science and technology or the human values of science and technology can only be seen as irrational, i.e. as being characterised by nothing but taste. And as we all know, there is no rational discussion possible about taste: *chacun a son goût.* That is the common view.[2] Habermas, in particular, has tried to show in various of his publications how the initial optimism of the Enlightenment concerning science and technology appears to have reverted to its opposite.[3] The increasing and anonymous bureaucratisation of society is regarded as a development which is no coincidence. The ultimate result of that development is a perfect dichotomy between the domain of bureaucratic and technical decisions about the organisation of society on the one hand, and the social environment familiar to us on the other. There are both philosophers and laymen who represent the view that technological progress does not so much lead to the further emancipation of our humanity (the belief peculiar to the Enlightenment) as constitute a threat to that same humanity.
Seen against this background, the questions that have been asked as a product of the

synthetic treatment have not appeared out of the blue. They are almost all questions which might equally be asked with reference to large-scale technology.
Yet it is still important to try to formulate an answer to these questions. As for as information technology is concerned we are at last in a position to ask such questions at the beginning of the process of development. In the case of the technologies which have shaped our industrial society they only acquired their vital urgency at a relatively late stage. At the same time it is important to realise that answers to these questions can scarcely have any higher status than that of what one hopes will be sensible recommendations. In view of the foregoing this much will already be clear.

It seems to me that the question of whether an uneven distribution of elementary knowledge of the new information systems is ethically undesirable is easily answered. In our democratic societies giving the ordinary citizen the greatest possible say is still seen as an ideal worth pursuing. Yet it is precisely the uneven distribution of elementary knowledge about science and technology that is becoming a major threat to that democratic right. We shall therefore have to do all we can to avoid such a situation, and this leads me to recommend, emphatically, that on the basis of this moral and political desirability everything possible must be done to ensure that children are made familiar with information science and information systems at the earliest possible stage of their schooling. Play must fulfil as important a role in the way children learn about the potential of computers and the way they work as it does in their learning of relevant and elementary arithmetical functions.

How far should we go in adapting new information systems to their future users? It seems to me that the answer to the previous question at least provides one criterion for dealing with this one. Participation, or the democratic imperative, embraces independent judgment. In that connection it seems important to me that users should in principle be aware at all times that they are dealing with an instrument which is there for their use, and not with a superior model of *Homo sapiens* to which they are in some way subject. Consideration must be given to how far, alongside the training and education of the population, the context and design of the new information systems can be so organised that this principle is guaranteed as far as possible. In effect, this is sufficient indication of how the necessary caution must be exercised in imitating humans. Elsewhere it has been pointed out that people have a tendency to anthropomorphise complex systems. In view of that fact I consider it desirable that proper account should be taken of the implications of any increased man-machine similarity for the democratic imperative.

To what extent should a machine imitate man? Will there be increasing alienation as machines begin to resemble people more and more as regards their intelligence and sensory capabilities? I do not believe that there is any easy answer to these questions. For example, let us consider some suggestions on a very special case: computer chess.
Recent research into the acceptance of chess-playing computers by human chess players has shown that, at least as regards chess machines, there is a wide range of possible approaches to the problem. A chess player who permits himself to regard man as a machine composed of DNA will have few difficulties in accepting chess computers. One who attaches great importance to the value placed on subjective feelings by the individual is likely to be extremely suspicious of the participation of chess computers in tournaments, since he will perceive it as unfair that, despite all the apparent equivalence of competence between the computer and himself, the computer has unfailing access to its own memory and at the same time can unfailingly perform its own procedures, whereas he can make mistakes, is under constant pressure and may even be subject to all sorts of physiological ailments. Some players, indeed, go so far as to perceive such a comparison as a form of

deception. It is not implausible that here again the usage context plays a major role. It makes quite a difference whether one has to play against a machine in a tournament or whether one uses a machine for practice before a tournament. I shall return to this in my answer to the next question.

To what extent does the availability of large quantities of information erroneously suggest that the quality of decisions will be improved? At the intuitive level it is indeed easy to overestimate the capacity of computers to take decisions, and there are many examples in science fiction. In fact, though, elementary user knowledge and experience play just as important a role as in the previous question. A person who takes account of the way in which decisions are arrived at via complex search trees and the use of heuristic methods will be less likely to exaggerate the possibilities than an uninformed layman. In fact, naive views of the significance of information quantity for the quality of decision-making are likely to be corrected of their own accord as time passes. Where formidable quantities of information are involved, it becomes more difficult to select the items which are relevant to the decision to be made. But this speculative suspicion that there is a natural brake on exaggeration in no way detracts from the importance of good education in information science in order to put the significance of information storage in computers into its proper perspective.

This brings me, finally, to some questions which are more specific, such as whether we have innate procedures for communication which might be taken into account in the design of new information systems, or how habituation to oral communication with machines is likely to occur. Answering these two questions may show how difficult it is to formulate predictions in this field. In some respects our knowledge of the structure of linguistic competence in humans is still extremely inadequate. For example, two controversial issues are whether there are culture-independent, innate linguistic abilities, and whether we learn communication procedures by starting from particular elements (the traditional view) or by first learning larger lumps in which elements allow themselves to be crystallised out at a later stage (the more recent view). We do have some evidence for the thesis that imitation plays a major role in language learning at an extremely early age, which makes it plausible that cultural determinants are introduced at an extremely early stage in the process. However, until both these disputed questions have been settled there is not much that can be said about the question as asked, though I would observe in passing that our meagre knowledge of the instrument that perhaps most sets *Homo sapiens* apart from other animals, i.e. language, is illustrative of the fact noted above that we have little reliable anthropological knowledge to go on. Seen in this light there is not much to be predicted about the influence which verbal communication with machines will have on the way we use them and interact with them.

I do not think that there are *a priori* reasons for assuming that people will not accept speaking computers, though here again much will depend on the context (for example, what the machine says in what kind of circumstances) and the degree to which formal education prepares people for living with computerised machines. The question of whether talking computers will affect the development of natural language again challenges one to indulge in speculation. It may be observed that until now the form of certain scientific languages (their formal and deductive character) has had little effect on the natural usage of members of the scientific professions. If we accept Quine's view of language as a social activity, the influence of computers on the spoken language will depend partly on the degree to which people regard computers as members of the same linguistic social group [160]. And the attitude which I have adopted in these brief comments implies that I regard it eminently desirable that this last possibility be minimised.

Notes

1. These questions were formulated by the authors of Chapter II
2. This view has a long philosophical tradition. In fact it was foreshadowed by the eighteenth-century philosopher David Hume. Within logical positivism it may be found among the Emotivists, who defend the thesis that moral 'assertions' are not really assertions but rather have the status of emotional expressions of subjective feelings. See [156].
3. See [157], both for a clear exposition of Habermas's view and for further references. For a similar philosophical involvement by an analytical philosopher the reader is referred to [158].

V Conclusions and unresolved questions

1. Conclusions

The importance of user affinity
It seems that electronic information systems will become an indispensable adjunct and supplement to human performance. On this level user affinity is probably more important than in the case of other technical aids which merely serve as extensions of muscle, bone and the senses.

The concept of user affinity
The user affinity of information systems is defined as a measure of the quality of the exchange of information between human beings and a technical system. User affinity can be broken down into a large number of aspects which fall into one of five categories: perception and motor functions, knowledge, emotions, environment, and organisation. Due consideration should be given to these aspects. Design criteria can be formulated by comparing aspects of user affinity with what is known about human behaviour patterns and the way organisations function. This need not lead to conflicting design requirements.

Problems
User affinity is particularly important when learning how to work with an information system. The main problems in this area are the adaptability of the system to the user's knowledge, and the standardisation of interface components, codes, language, system configuration, and so on.

User affinity would benefit greatly from the standardisation of the conceptual framework for information systems and the concomitant standardisation of interface components. This is necessary in order to present users with a clear-cut structure and to enable them to comprehend and control the system.

'Internal representation' is an important area for research. What picture and expectations does the user have of the operation and content of the information system? How does he arrive at that picture?

Practical research
Theoretical research is not expected to contribute greatly to our understanding of user affinity in the short term. Reality is often far more complex than the armchair expert suspects, so research on the actual use of information systems is of paramount importance.

Design
The user affinity of information systems could be significantly improved by applying the rules of elementary ergonomics and design theory, and by drawing on the large pool of expertise that already exists. Even at this date this applies to the layout of the human interface, to operating components, and to the presentation of information.

It is necessary to use good checklists. Although there are fairly comprehensive guidelines for keyboard design and data presentation they are often ignored. There are few guidelines on cognitive and emotional interaction.

Information systems are not human
User affinity must not lead to a situation in which users start to overestimate the nature and capacities of the service provided by a purely technical system. Thought must be given to ways of making the context and presentation of new information systems conform to this principle.

Friendliness: the user knows best
In principle it is not right that a system designer should lay down the law on what is friendly and what is not. Any unnecessary 'mothering' of users should be avoided. A user-friendly system is one which the user can adapt to his own specific requirements.
Individual comfort which can be selected by the user not only benefits regular users, but is perfectly feasible. The absence of much of the comfort in information systems is the result of a historical evolution. The cost price of hardware is now at such a relatively low level that the introduction of software into existing systems could raise not only the general level of comfort, but also the individual level.

The lack of comfort in present systems is also due to the fact that, in the past, users were computer specialists, enthusiasts or pioneers, and they were both able and willing to adapt themselves to the system. Present and future users expect far more comfort and are less willing to adjust to the demands of the system.

Linguistic skill
The linguistic skill of information systems can greatly enhance user affinity. This is a rapidly developing research area, but it must be said that there is a tendency to overestimate the rate of progress. A great deal of basic research still remains to be carried out. Modern dialogue systems still operate in a very limited knowledge domain whose expansion would be extremely labour-intensive, as well as making great demands on storage capacity and requiring powerful machines.

Dialogue systems can considerably improve the accessibility of information systems. This is particularly important for beginners and occasional users.

The cost-benefit ratio of dialogue systems is still prohibitive for commercial applications. In the long term dialogue systems will be used in areas where demand is backed by purchasing power, as in the case of members of the professions who have no technical training but who need an information system for their work or for consulting information stored in a documentary system.
Very simple dialogue systems are even now economically viable.

Speech technology
The development of electronic speech synthesis and automatic speech recognition will benefit the user affinity of information systems. First, though, there will have to be a considerable improvement in reliability.

The question of when speech is preferable in the interaction with information systems is an area which is as yet largely unexplored.
However, one guiding principle can be found in the functional differences between speech and text. Speech is often preferable for warnings or for emotional or personal messages, and it is often the best medium for rapid man-machine dialogues.

A great deal of basic research still remains to be done on speech recognition.

Introduction and user participation
User affinity is not exclusively a characteristic of systems, but is partly determined by the way in which those systems are introduced.

Improved acceptance and use can be expected if users are involved in the design stage, if there is latitude for individual adjustment, and if introduction is carefully supervised.

The information system in the organisation
The user affinity of information systems for an organisation is determined by effectiveness, efficiency, durability, and the degree of integration.

One major problem concerning effectiveness is the relevance of the information for the user.

In practice it emerges that it is extremely difficult to determine the efficiency of a system. This is because the effects are sometimes unquantifiable (such as quality improvements), and often mean more to the organisation than the actual fulfilment of a task by the man-machine system.

The degree of integration is determined by the extent to which information systems fit into the structure of the organisation. It is usually impracticable to incorporate a single, all-embracing system in an organisation because of the resultant complexity. However, the formation of 'islands of computerisation' can be prevented by drawing up an architecture for information processing, by establishing standards for data definitions and codes, and for design methods and documentation.

The ideal strategy for system development is to create aids which enable even those who are inexperienced in the use of computers to define and generate their own systems. This would eliminate the need for most of the 'middlemen' specialists, many of whom actually cause bottlenecks and delays.
Those specialists could then turn their attention to other tasks, such as ensuring that there is an adequate information infrastructure covering shared data banks and networking facilities, and coordinating system development from an overall architecture for information processing and computerisation.

Computer literacy
When one sees the ease with which so many children now work with reasonably complex information systems one can assume that there will be a gradual decline in computer illiteracy.

In the interests of promoting public participation it is recommended that children should become acquainted at school with the capacities and limitations of information systems at the earliest possible stage.

Information quality
Exaggerated ideas on the link between information quantity and decision quality will probably correct themselves in the years ahead. However, the importance of seeing the significance of information storage in its proper perspective makes it all the more vital that children receive a good education in information science.

2. Unresolved questions

The importance of user affinity
To what extent is the lack of user affinity proving an obstacle to the use and penetration of information systems?

Design
There is a feeling that the design of information systems could benefit greatly from experience drawn from a wide variety of other areas, such as the printing industry (notably typography), aircraft cockpit design, and so on. Which disciplines could provide the greatest contribution, and how can this cross-fertilisation best be achieved?

User affinity is an interdisciplinary field. The technical designers of systems pay too little heed to existing knowledge, experience and guidelines. How can this be corrected?

Presentation of information
Text has a tremendous potential for the transmission of information, but it also has its limitations. Text appears to be well suited to the transmission of theoretical knowledge and academic wisdom, and it also has its advantages for the communication of some forms of practical expertise. On the other hand, operating instructions are often incomprehensible. The flow of information between man and machine usually takes the form of written text. Since there will be a sharp increase in the use of electronic information systems it would be valuable to have an understanding of the distinctive capacities and limitations of text as a medium for transmitting information.
Why do human beings sometimes find it so difficult to assimilate written texts? What are the conditions which bring about this 'information block'? What are the consequences for the use of information systems in which text is the main means of communication?

Visual information can be presented in the form of letters and digits, or by means of visual codes, diagrams, graphs, or even moving displays. What, in general terms, are the advantages and limitations of these forms of visual information presentation? Is it possible to establish whether a particular kind of information could best be presented in one particular way? What are the determining factors? For example, to what extent does it depend on the user's educational standard?

Consumer classification of information systems
Has the time not come to classify information systems (particularly those aimed at the general public) along the lines of information labelling on foods so that the prospective user has a clear idea of their privacy level, conceptual level, etc? Clarification would benefit user affinity.

Task allocation
The man-machine entity carries out a function in which both elements have their own tasks to perform. It appears that the problem of mental load necessitates a careful allocation of tasks which does not necessarily match the greatest degree of computerisation. Is the erosion of the human task as a result of computerisation a beneficial or pernicious development? Is the machine really taking over the unpleasant, routine tasks, leaving the human being to devote his energies to the more creative work? Or is the reverse happening? Or do some people enjoy routine tasks? How should we view this?

User participation
When designing information and computerisation systems it is difficult to strike a balance between the role of experts and that of the many other individuals involved. Should we not give greater weight to the development of a differentiated design strategy which maintains a balance between an excessively technocratic approach and a never-ending process of participation?

The information system in the organisation
The introduction of information systems in an organisation has a major impact on the structure of the organisation and on communication processes. This must be taken fully into account when the system is designed. However, it is also true that management and the organisational structure will ultimately have to adapt to the system. How can one gain an insight into these developments? What is the best way of supervising the transitional processes, and how can they be anticipated? What demands does the transitional process make on the flexibility of individuals, the organisation, and the information system?

Bureaucracy versus decentralisation
The complex structure of information and computerisation systems sometimes makes them appear so menacing that the many people involved seek refuge in a plethora of rules and procedures. This leads to an increase in bureaucracy and an impenetrable corporate complexity. Calls for decentralisation and increased access to decision-makers are getting louder, but is practice not lagging behind rhetoric?

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Information systems are penetrating into every corner of modern society. They are affecting the lives of more and more people: as consumers, at work, at school...... everywhere.

It is this that makes the effectiveness and personal comfort of using these systems so important. This is referred to in this report as 'user affinity', meaning the degree to which the systems are designed to conform to the capacities and limitations of human beings.

The study opens with a number of practical case histories in order to illustrate the main aspects of user affinity and to identify current problems in this area.

Those practical experiences are then summarised in a synthesis. This is followed by the views of ten experts from various disciplines on improvements which could be made to user affinity in the future.

Some major improvements could be made almost immediately.

The report closes with a list of conclusions and unresolved questions.

The study will be of value to all who are involved in the use of information systems: those who frame the policy for the introduction of these systems, the users themselves, scientific researchers and, above all, systems designers.

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